Samuel Kai Wah Chu · Rebecca B. Reynolds
Nicole J. Tavares · Michele Notari
Celina Wing Yi Lee

21st Century Skills Development Through Inquiry-Based Learning

From Theory to Practice

Springer

21st Century Skills Development Through Inquiry-Based Learning

Samuel Kai Wah Chu · Rebecca B. Reynolds
Nicole J. Tavares · Michele Notari
Celina Wing Yi Lee

21st Century Skills Development Through Inquiry-Based Learning

From Theory to Practice

Springer

Samuel Kai Wah Chu
Faculty of Education
The University of Hong Kong
Hong Kong
Hong Kong

Rebecca B. Reynolds
Rutgers, The State University of New Jersey
New Brunswick, NJ
USA

Nicole J. Tavares
Faculty of Education
The University of Hong Kong
Hong Kong
Hong Kong

Michele Notari
University of Teacher Education
Bern
Switzerland

Celina Wing Yi Lee
Faculty of Education
The University of Hong Kong
Hong Kong
Hong Kong

ISBN 978-981-10-2479-5 ISBN 978-981-10-2481-8 (eBook)
DOI 10.1007/978-981-10-2481-8

Library of Congress Control Number: 2016949573

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #22-06/08 Gateway East, Singapore 189721, Singapore

Foreword 1

Globally, there is much talk about the importance of learning the twenty-first century skills and practices, which go beyond traditional content learning to include cross-cutting skills that span across disciplines, such as problem solving and information literacy as well as softer skills such as collaboration. The twenty-first century skills standards seem to demand inquiry-oriented approaches to learning without explicitly saying so. That is what makes the current volume so timely as it bridges these new standards for learning with enabling pedagogies and technologies.

I am delighted to write a foreword to this volume written by this particular group of international collaborators. In this book, *21st Century Skills Development Through Inquiry-based Learning: From Theory to Practice,* Chu, Reynolds, Tavares, Notari, and Lee bring together three of the most important contemporary topics in educational research as they address the twenty-first century skills in technology-rich inquiry learning environments. Within each of these topics, the book works at integrating across frameworks for a range of standards, as well as varying inquiry-oriented pedagogies. As they review the definitions of twenty-first century skills, they consider what different frameworks have established as contemporary guiding educational tenets, and then they do the important job of helping the reader see the intersections among frameworks, and how they align in the three very different national educational contexts of Hong Kong, Switzerland, and the United States.

A key theme that runs through the book is the ambitious teaching and learning practices that are integral to inquiry-based learning environments. These are ambitious for teachers in that they will need to be prepared to adapt to the directions that learners take in their inquiry. These are ambitious for learners, as much is expected of them, as they become active agents with heavy responsibility for their own learning. Inquiry-based learning environments are ambitious in the type of new approaches to instructional design and assessment that are needed. The challenges are considerable as they are at variance with teachers' learning histories and even the current generation of students' learning experiences. It requires a high level of

technology, information literacy, and media literacy that are twenty-first century skills for teachers along with the students they teach. An important feature of this book is that the authors tackle these important issues without glossing over the challenges but by providing evidence-based insights for addressing these challenges.

As a scholar of problem-based learning (PBL) for more than 25 years, I have seen few volumes that coherently address a range of inquiry-based learning approaches. They focus on the common prospects and challenges across these approaches in multiple cultural contexts rather than trying to figure out how they are unique. Finally, they finish with concrete sets of advice for teachers, researchers, school librarians, and policy makers. I especially would like to highlight the role of librarians as one of the defining features of inquiry-based approaches that help them afford learning twenty-first century skills are the demands for information literacy. Much work on PBL and iPBL leaves the role of support for information literacy tacit. By addressing the role of the school librarian in this support, this work asserts and affirms the ongoing relevance of this integral role in the constellation of school leadership. If schools of information science and school library programs do their jobs well, school librarians should be eminently prepared to support learners in technology uses for inquiry, information-seeking, and information literacy development. In summary, anyone who is considering using inquiry-based learning to support learning twenty-first century or pursue research or policy in this domain will benefit greatly from the lessons captured within the pages of this volume.

Dr. Cindy E. Hmelo-Silver
Professor, Learning Sciences
Indiana University
Director, Center for Research on Learning and Technology
Director, 4C Lab
Barbara B. Jacobs Chair in Education and Technology
Indiana University

Foreword 2

This book's focus on inquiry-centered approaches to student engagement is timely. Presently, educational systems around the world are grappling with the complexities of what constitutes meaningful and powerful learning for young people growing up in dramatically changing technological, social, and cultural environments. The challenges are enormous. Deep questions are being asked around the efficacy and legitimacy of education and curriculum practices rooted in the traditions of past decades. These revolve around teacher-centric instruction, prescription of knowledge and competency standards, standardized approaches to testing and assessment, and coming to terms with the complexities of information technology integration that goes beyond passive searching and finding, and transfer and transmission of information with low levels of intellectual engagement.

We are at a significant educational crossroad. One the one hand, there are concerted calls for a deliberate, deep, and sustained focus on deepening and enriching the learning experience and outcomes of students, with attention being given to meaningful engagement, construction, creation, problem solving, communication and collaboration. On the other hand, educational practices and assessment approaches continue to embody standardization and competition, cooperation rather than collaboration, content knowledge and basic literacy skills and the regurgitation of factual knowledge. The enormous gap between rhetoric and reality continues to be a stark reminder of the challenges ahead.

John Dewey, in his provocative book "Experience and Education" states as follows:

"The belief that all genuine education comes about through experience does not mean that all experiences are genuinely or equally educative. Experience and education cannot be directly equated to each other" (Dewey 1938, 25). Dewey continues to challenge us today to actively disrupt traditions and practices that do not enable and enrich learning and life experiences, and provokes us to ask why we continue to struggle with these fundamental issues. He later writes: "There is, I think, no point in the philosophy of progressive education which is sounder than its emphasis upon the importance of the participation of the learner in the formation

of the purposes which direct his [sic] activities in the learning process, just as there is no defect in traditional education greater than its failure to secure the active cooperation of the pupil in construction of the purposes involved in his studying" (Dewey 1938, 67).

Dewey's perspectives highlight why this book is fundamentally so valuable and critical. The transformation of education is first and foremost about transforming ourselves as educators: developing both our own pedagogical awareness and our own instructional capacity that focuses on student inquiry, critical engagement with information in all its forms, and how we engage with collaborative, networked technology to empower and enable depth of learning. The book charts a range of social constructivist pedagogical approaches centering on inquiry, their underlying pedagogical assumptions and principles, and the empirical research that directs, informs and challenges the learning process. The diverse approaches presented here immerse students as partners, collaborators and creative producers in the design and process of their learning, and showcase the essential complexity of developing technical, intellectual, and reflective capabilities to enable this learning to take place in powerful ways.

At the heart of inquiry-centered learning is the inquiry question. Thinking is driven by questions, not answers. Students engaged in inquiry construct their own meaningful questions, refine and improve their questions, strategize on how to design and produce responses to their questions, and to communicate, share, and reflect on the process, outcomes, impacts, and implications. And here we confront the essential paradox of the question: in order to ask one must know enough to know what one does not know. The book provides both a vital starting point for us as educators to question and to come to know our own perspectives on learning, our own frames of reference, our own assumptions and beliefs about learning, and then to advance our pedagogy through the rich elaboration of the approaches provided here.

Dr. Ross J. Todd
Associate Professor, Director, Center for International
Scholarship in School Libraries
School of Communication and Information
Rutgers University

Reference

Dewey, J. (1938). *Experience and Education.* New York, Kappa Delta Ki. Available at: http://elibrary.kiu.ac.ug:8080/jspui/bitstream/1/1431/1/Experience%20and%20Education_0684838281-%20Dewey.pdf

About the Book

This book presents innovative instructional interventions to support inquiry project-based learning as an approach to equip students with twenty-first century skills. Instructional techniques include collaborative team-based teaching, social constructivist game design and game play, and productive uses of social media such as wikis. The book will be of interest to researchers seeking a summary review of recent empirical studies in the inquiry project-based learning domain that employ new technologies as constructive media for student synthesis and creation. The work also offers a crosswalk from empirical works to a range of national- and international-level educational standards frameworks such as the P21, the OECD framework, AASL Standards for the 21st Century Learner, and the Common Core State Standards in the U.S. For education practitioners, the book gives a detailed description of inquiry project-based learning interventions that can be replicated in today's schools. Further, the book provides research-driven guidelines for assessment and evaluation of student inquiry project-based learning. Finally, this work may guide education policymakers in establishing anchors and spaces for inquiry project-based learning opportunities for today's youth, to inspire, motivate and engage them in transformative social constructivist knowledge-building with lasting impact, as well as to prepare them with a mindset and dispositions conducive to dealing with present-day societal challenges.

Contents

Part I
Twenty-First Century Skills Education on the Whole

Chapter 1
Introduction

Technology is radically transforming teaching and learning, as inquiry-based digital information resources and creative tools are made available to learners, schools, and educators. This book explores ways in which traditional models of education are evolving, and discusses a range of inquiry-based pedagogical approaches that more fully leverage learner agency and motivational capacity. The book is directed toward anyone interested in the ways in which adaptations to conventional didactic teaching and learning approaches are opening up new doors for individual and collaborative knowledge construction and sharing. Potential readers include academic researchers, education practitioners, policymakers, parents, and e-learning service providers who wish to support an evolving set of skills and knowledge in learners to prepare them well for active engagement in the drastic technological changes in the twenty-first century. Readers will find theoretical, empirical, and pragmatic discussions on inquiry- and project-based teaching and learning approaches as they are being implemented in schools in Asia, Europe, and North America.

Specifically, the book provides a synthesis of theoretical perspectives on inquiry- and project-based learning with technology, alongside research-driven pedagogical strategies for implementing inquiry projects encompassing collaborative teaching and learning, students' online research, digital project creation, and social media uses, all staged in various school settings. The book also provides comprehensive discussions around a knowledge domain that has come to be known as "*twenty-first century skills*". Existing education technology standards and frameworks offered by national organizations and government education departments are explicated, synthesized, and juxtaposed (e.g., Metiri Group & NCREL 2003; OECD 2005; Partnership for 21st Century Skills 2009; American Association of Colleges and Universities 2007; 21st Century Schools 2010). Empirical evidence collected from well-designed and extensive research studies investigating teaching and learning utilizing such approaches is highlighted. Specific programmatic recommendations are also offered, drawing upon established research findings. Pedagogical approaches toward twenty-first century skills are investigated based on concrete examples

S.K.W. Chu et al., *21st Century Skills Development Through Inquiry-Based Learning*, DOI 10.1007/978-981-10-2481-8_1

of implementation studies being conducted by the authors across three continents, Asia, Europe, and North America.

All nations around the globe face a growing set of shared problems that will require innovative thinking, resourcefulness, and resilience among the worlds' populations. These challenges include climate change, natural resource shortages (e.g., energy, water), injustices involving race and gender, and socio-economic inequalities and human rights abuses, to name but a few. Addressing these challenges will require cultivating a population that is awake to the problems and impacts, and that is adaptable and focused on identifying creative solutions for change. Further, education technology imperatives are swiftly changing worldwide, spanning from the government policy level with new education technology agenda, to the level of innovative research and development (R&D) in the academic and technology sectors where targeted learning technologies are proliferating, to the level of pioneering educators who are independently forging their own paths of imaginative and creative technology education, using the myriad existing free tools and resources that have been designed more for knowledge production in business. For these reasons, we adopt an international approach that highlights these current educational efforts, centering on human agency, as they are occurring around the world. Care has been taken to situate our analyses in discussions of constraints and affordances contributed by the cultural, sociopolitical, educational systemic and infrastructural differences present across contexts. Overall, the work focuses on demonstrating how inquiry-based pedagogies with similar commonalities in learning objectives and with theoretical foundations in social constructivism are playing out in the international settings we foreground.

Education practitioners (e.g., teachers, school librarians,[1] administrators) and parents can refer to this material when seeking empirical social scientific evidence for the effectiveness of various pedagogical approaches toward the development of twenty-first century skills. For those who are eager to try out pedagogies to sharpen students' twenty-first century skills, the book also covers a discussion of teaching strategies and proposed curricular implementation sequences, with a particular emphasis on teachers' roles, and samples of assessment materials that reinforce the pedagogical approaches outlined.

1.1 Goal for the Book: Fostering Meaningful Learning Experiences and a Love for Learning

> Education is the kindling of a flame, not the filling of a vessel.—Socrates

Socrates, the great philosopher, put forward the well-known metaphor of education as "kindling a flame", implying that education is anything but forced, didactic or

[1]School librarians are called teacher librarians in some parts of the world (e.g. Hong Kong), as they are qualified as a teacher and have some years of teaching experience.

top–down in nature. Unfortunately, global educational approaches are rarely so enlightening. Most students today attend classes day after day and experience rote learning and top–down instruction, without a clear understanding of how their in-school engagement connects to the world outside their classrooms and their future life and livelihood possibilities. Many students sadly become bogged down and overwhelmed by endless problem sets, assignments, and exams. If you have the pleasure of interacting with young children frequently, you will likely have met some very intelligent and bright pupils whose passion for knowledge seeking has slowly become shadowed by the pressures inherent to today's school cultures. Long anticipated holidays have also been transformed into dreadful revision periods because schools may purposefully schedule tests directly right thereafter. Many schools have inevitably become soulless factories that demotivate, bore, and frustrate their students, who may never have the opportunity in school to realize the most valuable asset of humanity: a love for learning, facilitated by pursuit of one's curiosity through inquiry.

Learning environments hold potential to serve as fun and inspiring workshop settings, where students can engage in exciting project-based activities that integrate required curriculum material, while also simulating some aspects of real world "epistemic" contexts, challenging students to gain a richer understanding of learning material in a more situated, relatable way. Authors of the book have witnessed students developing a love for learning under project-based pedagogy interventions. One prime example is the case of a girl, who did not care much about school in the past, but after beginning an inquiry-project-based learning (IPjBL) program, became so devoted to her project work that she would carry with her to school every day a folder containing all the related materials, even though it was neither required nor necessary to do so. It is encouraging to all parties involved to use pedagogies that make learning enjoyable, engaging, and effective. Hence, this book addresses pedagogies that adopt such approaches, and illustrates operational ways in which educators may apply such learning conditions in their own classrooms.

1.2 Key Domains of Scholarship

1.2.1 Theoretical Perspectives of Influence

We present examples of technology-based pedagogy building upon the social constructivist perspective that is becoming more commonplace, at least in principle, among educational and information researchers and teacher training programs worldwide. Social constructivism has been regarded as one of the leading learning theories since the 1980s (Mayer 1996). Social constructivism is grounded on the belief that students will optimally learn when they can "identify problems of

understanding, establishing and refining goals based on progress, gathering information, theorizing, designing experiments, answering questions and improving theories, building models, monitoring and evaluating progress" (Scardamalia and Bereiter 2003, p. 1371). All the way back to the early twentieth century, Dewey (1916) asserted that learning occurs best when students engage in experiences that are meaningful and significant to them. Vygotsky (1987) likewise stressed the importance of providing learners with opportunities for active exploration to foster meaningful engagement that allows them to develop new metacognitive skills through peer and expert social interactions and through learning with socially situated texts. Such experiences enable students to build their personal conceptualizations of the world piece by piece, and make meaning of it, in the light of the knowledge they individually and collaboratively construct (Kuhlthau et al. 2007).

The approaches we address all center upon social constructivist approaches to teaching and learning. A key concept in social constructivist approaches to learning is scaffolding, which has been addressed in the learning sciences, especially in the area of problem-based learning (PBL) (e.g., Hmelo-Silver 2004, Hmelo-Silver et al. 2007; Hmelo-Silver and Barrows 2006; Hmelo-Silver et al. 2009) and self-directed learning (SDL) (Hmelo-Silver 2004). Through thoughtful and well-designed scaffolding, teachers guide students in their discovery of new learning by providing support, for instance, in the form of questions or demonstrations, or through facilitating their generation of hypotheses for explanations (Kuhlthau et al. 2007; Moran 2007). Hmelo-Silver et al. (2007) argue that such scaffolding is critical for students to learn in complex domains to avoid imposition of excessive cognitive load. What needs to be noted is that the task difficulty should be set within their zone of proximal development. In other words, the assigned tasks must be of a level of difficulty that are not only challenging to them, but also manageable and achievable when students are mentored and given guidance (Bee and Boyd 2002; Rogoff 1990; Vygotsky 1987). These social constructivist concepts are central to the implementation of inquiry-project-based learning (PjBL), and are expected to contribute immensely to students' independent learning and development of twenty-first century skills.

The following table summarizes a spectrum of the theoretical perspectives given emphasis in the book, underscored by earlier work on social constructivism (Table 1.1).

Project-, problem-, and inquiry-based learning reflect varying types of structure that support and guide learners, including direct instruction provided by the teacher, the scope and sequence of the curriculum and/or the digital learning and information environments, systems, and resources that may be utilized. In this book, we illustrate ways in which such approaches can leverage technology affordances to extend the potentialities of social constructivist learning even further. We propose that learners can enrich their subject knowledge in an engaging way in such settings, while cultivating twenty-first century skills such as digital and information literacies, reading and writing of digital texts, communication skills, research skills,

Table 1.1 Summary of constructivist approaches

Approach	Brief description	Exemplary References
Inquiry-based learning (IBL)	A learner-centered approach focusing on questioning, critical thinking and problem solving. The learner is actively involved in formulating the question/naming a problem	Chu et al. (2007), Kuhlthau et al. (2007), Harada and Yoshina (2004)
Project-based learning (PjBL)	An individual or group activity that is carried out over a specified period of time, resulting in an output (product, presentation, or performance)	Harada et al. (2008)
Inquiry PjBL	A combined approach of IBL and PjBL that engages learners in formulating a question/naming a problem within their areas of interest. The answers to the question and/or ways to solve the problem are generated through group activities that include information search, evaluation, and management. The entire process leads to an output (report and presentation) that comes into being through the use of digital technologies	Chu (2009), Chu et al. (2011)
Problem-based learning	A student-centered learning approach in which students work together to address an open-ended question through inquiry and problem resolution, within a learning environment that is designed and scaffolded to strongly support the needs of students with prompts and resources, as they do so	Hmelo-Silver (2004)
Constructionism	Student engagement in creation of a complex computational digital artifact is the focus, in which the student represents an abstract idea or principle in the representational artifact, through programming. Learners benefit from social interactions and sharing throughout the process of creating the artifact, in which the artifact expresses conceptual knowledge in a dynamic way. Educators act as expert mentors and facilitators, while peers help guide one another and students use information resources in a workshop-based environment that increases transparency of creative processes	Papert (1980), Harel and Papert (1991), Kafai (1995), Reynolds and Harel Caperton (2011)

computational literacies, and more. On the whole, we emphasize inquiry-based methods that draw upon students' inherent stores of motivation, effort and resiliency. We maintain that through engaging in the activities and experiences we

outline in this book, students will gain a greater self-awareness of their own inherent agency, which can have notable, transferrable effects upon their ongoing learning experiences, as well as life and livelihood goals and choices.

In the following sections we provide an introduction to the primary dimensions of the pedagogies we address throughout this work.

1.2.2 Twenty-First Century Skills

The twenty-first century, unlike any other period in human history, is characterized by the proliferation of technologies. The acceleration of technological advancement has made digital literacies essential for people in this information age (Black 2009). Globalization, too, has reshaped organizational and professional operations across the world, toward becoming more knowledge-based, geographically mobile, and collaborative in nature (Dunning 2000). Meanwhile, machines have increasingly taken the place of the human workforce in tasks that involve routine cognitive and manual input. Consequently, the labor force is now hiring people for jobs that require more analytical thinking, digital skills, and sophisticated communication skills (Levy and Murnane 2012). Alongside these advances, human civilizations face some of the starkest challenges yet experienced in the history of our species, in the threats to global ecosystems being charted by scientists. All too often, citizens feel disempowered that they can contribute solutions or innovations that are necessary to help address global dilemmas. Such challenges call for the cultivation of greater human agency, creativity, and an inquiry mindset that connect to feelings of productivity. We propose that the approaches discussed herein present this opportunity in the education context, with school-aged children, possibly more so than rote learning approaches.

Overall, education systems have not evolved in parallel, in infrastructure, pedagogical methods, or actual curricular material that will maximally prepare students for the current and future world in which they will enter and lead in their future. New sets of skills linking to the broader world challenges we all face, are needed, to equip learners with the capacity to negotiate the complexities inherent in today's global and knowledge-driven-economy (Asian Development Bank 2007). In broad terms, twenty-first century skills are "not new, just newly important" (Silva 2009, p. 631). Certain skills have been the center of attention for education institutions all around the world for over decades, such as language skills and critical thinking, while some other skills are more recently emergent, namely, digital literacies. Twenty-first century skills comprise three main knowledge domains: (1) innovative thinking; (2) information, media and ICT (information, communication, and technology) skills (collectively referred to as "digital literacies"); and (3) life and career skills (Trilling and Fadel 2009). The book identifies areas of convergence as well as divergence in these domains, and notes gaps that may still exist in such frameworks as areas for continued conceptualization and development.

1.2.3 Inquiry-Based Learning

Inquiry-based learning (IBL) is a pedagogical approach that engages learners actively in a knowledge-building process through the generation of answerable questions (Harada and Yoshina 2004). This approach is related to problem- and project-based learning, in which learners adopt an inquiry mindset in addressing epistemic issues or in developing and completing projects with a relatively open-ended set of answers. Such pursuits can occur within the context of short-term (e.g., single session) engagement, or longer-term (e.g., semester-long) assignments. Such learning scenarios may be structured formally or informally, and take on myriad forms.

For instance, an IBL project may comprise an interest-driven research question developed by the learner, assigned in a school context (Blumenfeld et al. 1991; David 2008; Marx et al. 1997; Thomas 2000). It may involve a more structured problem-based scenario designed by an educator or researcher to teach learners specific scientific or mathematical principles, requiring the learner to engage in inquiry, subject knowledge immersion and perhaps research and creation of an artifact for completion of the task. It could also present itself as a more open-ended interest-driven project in which learners pursue an idea or question that taps their innate curiosity (whether in or out of school). Such inquiry-based tasks share a theoretical underpinning in social constructivism, presuming that learners are active agents in building knowledge through constructing their own understanding and through meaning-making, which requires them to have an inquiry mindset. Research has found that more formalized, well-designed inquiry-based approaches are effective in promoting positive learning outcomes such as deep thinking, knowledge application and logical reasoning (Harel and Papert 1991; Dochy et al. 2003; Hmelo-Silver et al. 2007; Kuhlthau et al. 2007; Hu et al. 2008; Zmuda and Harada 2008).

1.2.4 Collaborative Teaching

As inquiry learning is a learner-centered approach that requires students to bear primary responsibility in knowledge construction and application, timely and appropriate instructional scaffolding interventions by the educator and/or the digital learning environment are of paramount importance (Thousand et al. 2006; Chu et al. 2012b; Chu and Kennedy 2011; Richardson 2006). Furthermore, inquiry learning is, on the whole, multidisciplinary in nature, which calls upon learners to possess multifaceted skills and knowledge, such as reading skills, presentation skills, information, and computer skills (Chu et al. 2012b). Since it would be rare for one single teacher to cover all these skills and knowledge in his/her teaching, a

collaborative teaching team involving various subject teachers is essential to guide learners in developing these different skills. This book puts forward a collaborative inquiry-project-based learning model that brings together front-line teachers, school librarians, and administrative staff working closely together, and suggests an inclusion of parents.

1.2.5 Collaborative Learning

Collaborative learning stresses the joint intellectual efforts among learners and/or between learners and teachers (Coyle 2007). Learning outcomes such as reports or presentations may be co-constructed by a small group of learners for demonstration of cultivated knowledge (Smith and MacGregor 1992). Collaborative learning has been found beneficial to the catering of learner diversity, as its focus on social and intellectual interactions embraces differences in knowledge, skills, and attitudes among learners and turns such differences into useful resources (Hartley 1999). On top of subject knowledge, collaborative learning provides learners with an opportunity to sharpen their communication and negotiation skills (Gros 2001; Smith and MacGregor 1992), as well as analytical skills for interpreting information (Lowyck and Poysa 2001).

1.2.6 Social Media for Learning

One of the hallmarks of the rapid technological advancement in the twenty-first century is the emergence of the social media. Since technology has remarkably shaped the knowledge and skills demanded from students (Dede 2009), integrating social media technology into mainstream education has become more commonplace. While educators are forging ahead in experimenting with the new pedagogical approaches that involve social media, education researchers are investigating how social media features and innovations (both existing and newly designed) can best be deployed to facilitate teaching and learning. As suggested by the existing literature, incorporating social media into education can be impactful (e.g., Richardson 2006; Chu and Kennedy 2011; Chu et al. 2012a).

Among all the types of social media tools available, the wiki, "a collaborative web space where anyone can add content and anyone can edit content that has already been published", is a popular tool for educational purposes (Richardson 2006, p. 8). Studies have demonstrated positive results regarding particular applications of wiki technology in meeting defined learning goals and objectives (e.g., Notari 2006; Chu 2008; Mak and Coniam 2008; Li et al. 2010; Woo et al. 2010, 2011; Fung et al. 2011; Law et al. 2011; Pifarre and Kleine Starrman 2011; Tavares et al. 2011;

Yu et al. 2011; Reynolds 2016a). One of the benefits of bringing wikis into education seems to lie in the dialogic space wiki provides for participants' interaction (Pifarre and Kleine Starrman 2011). Another positive outcome of integrating social media into classroom teaching is that the technology encourages collaboration, and therefore enhances the quality of group work (Chu 2008) and the development of social skills (Fung et al. 2011). Chapters 3 and 4 of this book specifically examine the use of wikis as a kind of useful learning management system platform possible for deployment to maximize teaching and learning opportunities.

1.2.7 Gamification/Games for Learning

Gamification is another sphere of development that has been gaining attention for its potential to transform the educational technology landscape, given that young people nowadays are enthusiastic about video games. Gamification is widely defined as injecting game elements into traditional nongame contexts (Deterding et al. 2011). While the application of gamification is not confined to the educational setting, it has been found that when the concept is employed in the classroom, learners' motivation, cognitive, emotional, and social engagement can be promoted (Lee and Hammer 2011).

Educational game design projects have indicated that the creative production involved in designing artifacts enables learning and participation through the input of the individual, group collaboration, and the mediation of the artifact itself (Kafai et al. 2007). Salen et al. (2014) argue that games are systems and the same practices that are used in understanding Science, Technology, Engineering and Mathematics (STEM) content may also be useful for designing games. Learner discourse around designing science games has been shown to support active student engagement with science content; the nature and depth of the discourse has been found to vary with different aspects of design (Kafai and Ching 2004). In addition to making thinking visible in the design process, game design, like other forms of project- and problem-based learning, creates a "need to know"—an upfront purpose (designing a game) that drives students' inquiry and problem resolution (Hmelo-Silver 2004; Salen et al. 2014).

In this book we consider both gamification—the integration of gameplay elements into nongame contexts such as inquiry-project-based learning interventions, including rewards and incentives, point systems and leveling to encourage student perseverance—and game design, as pedagogical approaches that are conducive to inquiry-based learning (Reynolds and Harel Caperton 2011; Reynolds and Chiu 2015; Reynolds 2016a, b). We discuss ways in which varying types of motivational orientation play into the application of gaming principles in inquiry-project-based learning. Such approaches offer novel perspectives on enhancing inquiry-project-based learning that are newly emergent in the literature.

1.3 Organization of the Book

The organization of the book is inspired by the authors' experience in implementing twenty-first century skills education. With increasing references to twenty-first century skills and inquiry learning in education reforms, it is not uncommon that educators have heard of such skills and felt the need for their students to develop these skills. However, schools may not be fully prepared for the introduction of inquiry learning as it is a relatively novel form of pedagogy. In fact, the first author has heard reports of schools implementing inquiry learning too abruptly by introducing inquiry projects in each subject, which gave undue stress to both students and teachers as neither party was ready for the change. Therefore, the book is structured in way such that readers will understand what twenty-first century skills are and be empowered to help students develop such skills in a more gradual and systematic way.

For the convenience of researchers and teachers, the book is divided into three main sections. The first focuses on the theoretical frameworks around the topic while the later two present research-based evidence and practical teaching guides on the suggested pedagogy. The conclusion links back to the basic premises we setup in this introduction, and identifies some ongoing opportunities for research, development and practice, as well as challenges we anticipate, as digital learning environments online become ever-more quick and usable, and technology continues its perpetual march forward in sophistication and ubiquity. Overall we aim for this book to serve as an inspiring reference and starting point for our education researcher, and, practitioner colleagues and peers. We hope it encourages greater resource sharing of research-driven best practices, and challenges educators to think more deeply about their design of exciting and effective learning experiences for their students.

Part One (Chap. 2): Twenty-first century skills education on the whole
In this part, twenty-first century skill sets are introduced and discussed with a close link to the current school curriculum in Asia, Europe, and North America. As there are different models of twenty-first century skill sets, we attempt to present the similarities and differences between the models in a bid to capitalize upon their strengths.

Part Two (Chaps. 3–5): Twenty-first century skills education in Asia, Europe, and North America
A selected range of teaching strategies are recommended to foster learners' acquisition of twenty-first century skills. In this part, the supporting theories and research-based evidence from our projects carried out are detailed such that researchers and education practitioners are able to gain a deeper understanding of the basis and effectiveness of these methods. In particular, four forms of interventions (inquiry learning, collaborative teaching, the use of social media and game learning) that have been adopted in selected schools in Asia, Europe, and North America, respectively, to support twenty-first century skills education are examined and systematically analyzed.

Part Three (Chaps. 6–8): Implementation in schools
In the last part of the book, we target at providing specific and practical guidelines to researchers and education practitioners who wish to know more about how the suggested forms of intervention can be carried out in schools of different cultural settings. Detailed information on teaching strategies and proposed schedules, assessment methods, and roles of different teachers are included in the form of guidelines for readers' reference.

1.4 A Note About the Book's Drafting

The production of this book in itself is a living example of computer-supported cooperative work practices. Unlike traditional approaches to cowriting, the internationally distributed coauthors of this book have employed a variety of collaborative tools in the entire writing and editing process. In the initial phase, the authors made use of PBworks, a wiki platform, to draft a preliminary structure for the book and circulate important documents such as the book proposal and references. Later, the authors discussed the content of the book, drafted and edited chapters either simultaneously or individually on Google Docs while sitting in their offices in Hong Kong, Switzerland and the U.S. Every month, the authors held a video and/or audio conference via Skype to update the team on the work progress and to discuss the upcoming direction of and agreement on the action plan for the book. When it came to the editing stage, the authors moved all the manuscripts to a Dropbox shared folder for final editing using track changes. This is solid evidence to show how human life has been influenced by social computing capabilities in a positive and productive way, a direction one would like to take in education too.

References

21st Century Schools (2010). *What is 21st century education*? Retrieved April 22, 2015 from http://www.21stcenturyschools.com/What_is_21st_Century_Education.htm

American Association of Colleges and Universities. (2007). *College learning for the new global century*. Washington, DC: AACU.

Asian Development Bank. (2007). *Moving toward knowledge-based economies: Asian experiences*. Regional Sustainable Development Department, Asian Development Bank.

Bee, H., & Boyd, D. (2002). *Lifespan development* (3rd ed.). Boston: Allyn and Bacon.

Black, R. (2009). English-language learners, fan communities, and 21st-century skills. *Journal of Adolescent & Adult Literacy, 52*(8), 688–697.

Blumenfeld, P., Soloway, E., Marx, R., Krajcik, J., Guzdial, M., & Palinscar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist, 26*(3–4), 369–398.

Chu, S. K. W. (2008). TWiki for knowledge building and management. *Online Information Review, 32*(6), 745–758.

Chu, S. K. W. (2009). Inquiry project-based learning with a partnership of three types of teachers and the school librarian. *Journal of the American Society for Information Science and Technology, 60*(8), 1671–1686.

Chu, S. K. W., Chan, C. K. K., & Tiwari, A. F. Y. (2012a). Using blogs to support learning during internship. *Computers & Education, 58*(3), 989–1000.

Chu, S. K. W., & Kennedy, D. M. (2011). Using online collaborative tools for groups to co-construct knowledge. *Online Information Review, 35*(4), 581–597.

Chu, S. K. W., Tang, Q., Chow, K., & Tse, S. K. (2007). *A study on inquiry-based learning in a primary school through librarian-teacher partnerships*. Paper presented at the 36th Annual Conference of the International Association of School Librarianship, and the Eleventh International Forum on Research in School Librarianship. Taipai, Taiwan: International Association of School Librarianship.

Chu, S. K. W., Tavares, N. J., Chu, D., Ho, S. Y., Chow, K., Siu, F. L. C., & Wong, M. (2012b). *Developing upper primary students' 21st century skills: Inquiry learning through collaborative teaching and Web 2.0 technology.* Hong Kong: Centre for Information Technology in Education, Faculty of Education, The University of Hong Kong.

Chu, S. K. W., Tse, S., & Chow, K. (2011). Using collaborative teaching and inquiry project-based learning to help primary school students develop information literacy and information skills. *Library & Information Science Research, 33*(2), 132–143.

Coyle, J. (2007). *Wikis in the college classroom: A comparative study of online and face to face group collaboration at a private liberal arts university.* (Unpublished doctoral dissertation). Kent State University College and Graduate School of Education, Health and Human Services.

David, J. (2008). What research says about project-based learning. *Educational Leadership, 65*, 80–82.

Dede, C. (2009). Immersive interfaces for engagement and learning. *Science, 323*(5910), 66–69.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness defining gamification. In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments* (pp. 9–15). New York: ACM Digital Library.

Dewey, J. (1916). *Democracy and education*. New York: The Free Press.

Dochy, F., Segers, M., Van den Bossche, P., & Gijbels, D. (2003). Effects of problem-based learning: A meta-analysis. *Learning and Instruction, 13*(5), 533–556.

Dunning, J. H. (2000). Regions, globalization, and the knowledge economy: Issues stated. In J. H. Dunning (Ed.), *Regions, globalization, and the knowledge-based economy*. Oxford: Oxford University Press.

Fung, K. Y., Chu, S. K. W., Tavares, N., Ho, G., & Kwan, K. (2011). *Using Google sites in English collaborative writing*. Paper presented at CITE Research Symposium 2011, The University of Hong Kong, Hong Kong.

Gros, B. (2001). Instructional design for computer-supported collaborative learning in primary and secondary school. *Computers in Human Behavior, 17*, 439–451.

Harada, V. H., Kirio, C., & Yamamoto, S. (2008). *Collaborating for project-based learning*. Worthington, OH: Linworth Publishing.

Harada, V. H., & Yoshina, J. M. (2004). *Inquiry learning through librarian-teacher partnerships*. Worthington, OH: Linworth Publishing.

Harel, I. E., & Papert, S. E. (1991). *Constructionism*. Ablex Publishing.

Hartley, J. R. (1999). Effective pedagogies for managing collaborative learning in online learning environments. *Educational Technology and Society, 2*(2), 12–19.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*(3), 235–266.

Hmelo-Silver, C. E., & Barrows, H. S. (2006). Goals and strategies of a problem-based learning facilitator. *Interdisciplinary Journal of Problem-based Learning, 1*(1), 4.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist*, *42*(2), 99–107.

Hmelo-Silver, C. E., Derry, S. J., Bitterman, A., & Hatrak, N. (2009). Targeting transfer in a STELLAR PBL course for pre-service teachers. *Interdisciplinary Journal of Problem-based Learning, 3*(2), 4.

Hu, S., Kuh, G., & Li, S. (2008). The effects of engagement in inquiry-oriented activities on student learning and personal development. *Innovative Higher Education, 33*(2), 71–81.

Kafai, Y. B. (1995). *Minds in play: Computer game design as a context for children's learning.* Routledge.

Kafai, Y. B., & Ching, C. C. (2004). Children as instructional designers: Principles of learning with guided discoveries. In N. M. Seel & S. Dijkstra (Eds.), *Curriculum, plans, and processes in instructional design: International perspectives* (pp. 115–130). Mahwah, NJ: Lawrence Erlbaum Associates Inc.

Kafai, Y. B., Peppler, K., & Chiu, G. (2007). High tech programmers in low income communities: Seeding reform in a community technology center. In C. Steinfield., B. Pentland., M. Ackerman & N. Contractor (Eds.), *Communities and technologies 2007* (pp. 545–564). New York, NY: Springer.

Kuhlthau, C. C., Caspari, A. K., & Maniotes, L. K. (2007). *Guided inquiry: Learning in the 21st century*. Westport: Libraries Unlimited.

Law, H. C., Chu, S. K. W., Siu F., Pun, B. & Lei, H. (2011). *Challenges of using Google sites in education and how students perceive using it*. Paper presented at CITE Research Symposium 2011, The University of Hong Kong, Hong Kong.

Lee, J. J., & Hammer, J. (2011). Gamification in education: What, how, why bother? *Academic Exchange Quarterly, 15*(2), 146.

Levy, F., & Murnane, R. J. (2012). *The new division of labor: How computers are creating the next job market*. Princeton, NJ: Russell Sage Foundation.

Li, X., Chu, S. K. W., Ki, W. W., & Woo, M. (2010). *Students' and teacher's attitudes and perceptions toward collaborative writing with Wiki in a primary four Chinese classroom.* Paper presented at the 3rd International Conference "ICT for Language Learning", Florence, Italy.

Lowyck, J., & Poysa, J. (2001). Design of collaborative learning environments. *Computers in Human Behavior, 17*(5), 507–516.

Mak, B., & Coniam, D. (2008). Using wikis to enhance and develop writing skills among secondary school students in Hong Kong. *System, 36*(3), 437–455.

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., & Soloway, E. (1997). Enacting project-based science. *The Elementary School Journal, 97*(4), 341–358.

Mayer, R. E. (1996). Learners as information processors: Legacies and limitations of educational psychology's second. *Educational psychologist, 31*(3–4), 151–161.

Metiri Group & NCREL. (2003). *EnGauge 21st century skills: Literacy in the digital age*. Chicago, IL: NCREL.

Moran, M. J. (2007). Collaborative action research and project work: Promising practices for developing collaborative inquiry among early childhood preservice teachers. *Teaching and Teacher Education, 23*(4), 418–431.

Notari, M. (2006). *How to use a Wiki in education: Wiki based effective constructive learning*: *Wikisym 2006.* Paper present at the International Symposium on Wikis, Odense DK.

Organization for Economic Cooperation and Development [OECD]. (2005). *The definition and selection of key competencies: Executive summary*. Paris, France: OECD.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas.* Basic Books, Inc.

Partnership for 21st Century Skills. (2009). *P21 framework definitions*. Retrieved May 11 2015 from http://p21.org/storage/documents/P21_Framework_Definitions.pdf

Pifarre, M., & Kleine Starrman, J. (2011). Wiki-supported collaborative learning in primary education: How a dialogic space is created for thinking together. *International Journal of Computer-Supported Collaborative Learning, 6*(2), 187–205.

Reynolds, R. (2016a). Defining, designing for, and measuring "digital literacy" development in learners: A proposed framework. *Educational Technology Research & Development*. 64(1).

Reynolds, R. (2016b). Relationships among tasks, collaborative inquiry processes, inquiry resolutions, and knowledge outcomes in adolescents during guided discovery-based game design in school. *Journal of Information Science: Special Issue on Searching as Learning, 42*, 35–58.

Reynolds, R., & Chiu, M. M. (2015). Reducing digital divide effects through student engagement in coordinated game design, online resource uses, and social computing activities in school. *Journal of the Association for Information Science and Technology* (JASIST).

Reynolds, R., & Harel Caperton, I. (2011). Contrasts in student engagement, meaning-making, dislikes, and challenges in a discovery-based program of game design learning. *Journal of Educational Technology Research and Development, 59*(2), 267–289.

Richardson, W. (2006). *Blogs, wikis, podcasts and other powerful web tools for classrooms*. Thousand Park, CA: Corwin Press.

Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York: Oxford University Press.

Salen, K., Gresalfi, M., Peppler, K., & Santo, R. (2014). *Gaming the system: Designing with gamestar mechanic*. Cambridge MA: MIT Press.

Scardamalia, M., & Bereiter, C. (2003). Knowledge building. In J. W. Guthrie (Ed.), *Encyclopedia of education* (pp. 1370–1373). New York, NY: Macmillan Reference.

Silva, E. (2009). Measuring skills for 21st-century learning. *The Phi Delta Kappan, 90*(9), 630–634.

Smith, B., & MacGregor, J. (1992). What is collaborative learning? In A. Goodsell, et al. (Eds.), *Collaborative learning: A sourcebook for higher education* (pp. 10–22). Pennsylvania: National Center on Postsecondary Teaching, Learning, and Assessment.

Tavares, N., Chu, S. K. W., & Weng, M. (2011). *Experimenting with English collaborative writing on Google Sites.* Paper presented at QEF Project Dissemination Symposia: Applying a collaborative teaching approach to inquiry project-based learning with Web 2.0 at upper primary levels, The University of Hong Kong, Hong Kong.

Thomas, J. W. (2000). *A review of research on project-based learning*. San Rafael, CA: Autodesk Foundation.

Thousand, J. S., Villa, R. A., & Nevin, A. I. (2006). The many faces of collaborative planning and teaching. *Theory into Practice, 45*(3), 239–248.

Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times*. San Francisco: Jossey-Bass.

Vygotsky, L. S. (1987). Development of higher mental functions during the transition age. In R. W. Rieber (Ed.), *The collected works of L.S. Vygotsky* (pp. 83–150). New York: Plenum Press.

Woo, M., Chu, S., & Li, X. X. (2010). Tracing peer feedback to revision process in a wiki supported collaborative writing. *The Second Asian Conference on Education*, 1881–1898.

Woo, M., Chu, S., Ho, A., & Li, X. X. (2011). Using a Wiki to scaffold primary school students' collaborative writing. *Journal of Educational Technology & Society, 14*(1), 43–54.

Yu, C. T., Fong, C. S., Kwok, W. K., Law, S. M., Chu, S. K. W., & Ip, I. (2011). *Using Google sites in collaborative inquiry projects in general studies.* Paper presented at CITE Research Symposium 2011, The University of Hong Kong, Hong Kong.

Zmuda, A., & Harada, V. H. (2008). Reframing the library media specialist as a learning specialist. *School Library Media Activities Monthly, 14*(8), 42–46.

Chapter 2
Twenty-First Century Skills and Global Education Roadmaps

The twenty-first century is characterized by its rapid technological advancement. Our lifestyles and ways of interacting with people have changed significantly as digital technologies turn ubiquitous in our life. The twenty-first century, being described by Castells (2010) as a period of intense transformation, is an unprecedented era as business operations have become so globalized that core business competencies place greater emphasis on knowledge, mobility, and collaboration (Dunning 2000). Such businesses now call for a human workforce with expert thinking and complex communication skills (Levy and Murnane 2004) as machines replace human beings in routine and manual work. Today more than ever, education plays an integral part in preparing learners to become global and conscious citizens, and also to be ready for challenges associated with the highly mobilized and technology-dominated society (Berry 2010; Castells 2005). Scholars in the field of education have thus advocated the need for modifications to be made to the education system to support the development of the requisite skills and literacies (Dunning 2000; UNESCO 2003; Levy and Murnane 2004; Pigozzi 2006; Kozma 2008; Black 2009).

A range of international, national and more localized technology and information literacy frameworks have emerged to provide outcome benchmarks for the needed curricular reforms. In this chapter, we review a number of these frameworks for the twenty-first century and digital skills that have been adopted in different education policy environments around the world. We also look at education reforms in response to twenty-first century skills frameworks put forward by various organizations. While the thinking behind such frameworks proposed is certainly forward-looking in terms of learning outcomes, our study shows that the frameworks do not give a clear indication of how such valuable skills could be attained. Similarly, policy makers who decide to incorporate twenty-first century skills education into their curricula need to back up the changes with a well-articulated execution plan. By mapping out the current landscape of twenty-first century skills development, we will see these skills have a stronger presence in curricula and that

S.K.W. Chu et al., *21st Century Skills Development Through Inquiry-Based Learning*, DOI 10.1007/978-981-10-2481-8_2

there is an even stronger need for a detailed, well-researched approach to guide educators, school administrators, and policy makers through the intricate process of implementing twenty-first century skill education.

2.1 Frameworks Developed for Twenty-First Century Skills

Although the term "twenty-first century skills" might sound modern, some of these skills are "not new, just newly important" (Silva 2009, p. 631). Vital capabilities such as critical thinking and problem solving have always been essential. However, nowadays, because of the emergent demands of knowledge-based economies, these capabilities have gained increasing importance (Levy and Murnane 2004; Rotherham and Willingham 2009). Having said that, there are certain skills that are specific to the information era we are now living in. For instance, OECD (2004) and Pedró (2006) opine that due to the exponential growth of information any content may become obsolete in a few years' time; continual updating is the only way to meet the demands of the twenty-first century. It is expedient that everybody needs to be prepared for and convinced of the need to be lifelong learners to keep pace with the evolution of technology (Medel-Añonuevo et al. 2001).

UNESCO's Delors Report (1996) issued by the International Commission on Education for the Twenty-First Century analyzed the developmental trends of the century and concluded that continuing education would go far beyond what it was in 1996. Acknowledging the salience of continuing education in the twenty-first century, UNESCO recommended that education be built upon four key pillars: learning to know, learning to do, learning to live together and learning to be. These four pillars contribute to the notion of learning throughout life, which was defined as "taking advantage of all the opportunities offered by society" (p. 38). While this framework presented by UNESCO's Delors Report was the first of its kind that puts forward the central education functions in the twenty-first century, many other frameworks have subsequently been established to suggest how education should be adapted to meet the newly arisen needs induced by fast-paced technological progress in a knowledge-based economy (Enright 2000). Almost two decades after, UNESCO revisited the issue, this time investigating how the four pillars of education (how termed transversal competencies) (UNESCO 2015) are realized in schools.

With the aim of strengthening one's understanding toward twenty-first century skills, many frameworks have been drawn up under the support of international organizations, governments and consulting firms. Among the vast range of frameworks, three of them have been chosen to illustrate the emergence of the main ideas and notions. The three frameworks have been selected on the basis of their geographic origins and nature of their funding bodies. It is hoped that these frameworks would represent the different perspectives one holds toward

twenty-first century skills understood by both western and eastern societies, as well as by different education institutions and business corporations.

Before we embark on the discussion of these frameworks, please note that in a more general way, with reference to the capabilities that are deemed especially crucial for the twenty-first century, some organizations and scholars have been using the term 'competency' (Ministry of Education-Singapore 2010a; OECD 2005; UNESCO 2012) whereas others are more inclined to be using *skill* (Partnership of twenty-first Century Skills [P21] 2009; Voogt and Pareja Roblin 2010). As there is no standardized term coined for the sets of knowledge and skills induced by the twenty-first century (Ananiadou and Claro 2009), both terms are used interchangeably in this book.

2.1.1 International Frameworks

Framework based on Organization for Economic Cooperation and Development [OECD] countries (2009)
Developed by Ananiadou and Claro (2009), the OECD framework was detailed in a document entitled "*twenty-first Century Skills and competences for New Millennium learners in OECD countries.*" In an attempt to provide clear definitions and understanding of the skills and competencies related to the twenty-first century, the authors examined and critically reviewed the effects of Information and Communication Technology (ICT) on young people, together with the consequential changes in the teaching and assessment systems of some OECD countries (including Australia, Austria, Belgium, Canada, Finland, Ireland, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, and Turkey). Ananiadou and Claro also put together a framework based on the competences and skills found in those countries in relation to the role of ICT in education. The three major dimensions of the framework include (1) Communication, (2) Information, and (3) Ethics and Social Impact.

Assessment and Teaching of twenty-first Century Skills [ATCS] (Griffin et al. 2012)
The Assessment and Teaching of twenty-first Century Skills [ATCS] is an international research initiative headquartered at the University of Melbourne and sponsored by Cisco, Intel, and Microsoft (http://www.atc21s.org). The group aimed at identifying and helping learners acquire the necessary skills needed to be successful in the twenty-first century workplace. The research group devoted its effort to analyzing the roles of standards and assessments in promoting learning, taking into consideration the use of technology in transforming assessment systems and education. The ATCS categorized twenty-first century skills into four prime types, namely (1) Ways of thinking, (2) Ways of working, (3) Tools for working, and (4) Living in the world.

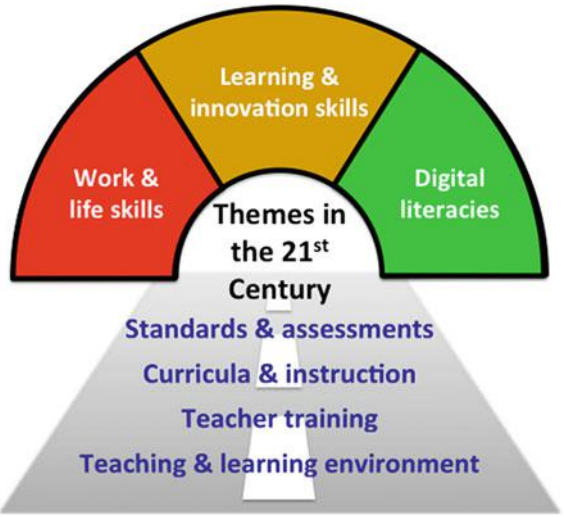

Fig. 2.1 Rainbow illustration of the partnership for twenty-first century skills framework (adapted from P21 2009)

Partnership for twenty-first Century Skills [P21] (2009)
This American organization founded in 2002 (http://www.p21.org), formed by business leaders, consultants, and educators, conceptualized a framework for twenty-first century skills. This framework has become well-known in the field of information technology (IT) in education (P21 2009). It consists of eleven competencies which are classified into three gist elements including (1) learning and innovation skills, (2) information, media, and technology skills, and (3) life and career skills. The framework also entails a support system that embodies standards, assessments, curriculum, instructions, professional development, and learning environments (see Fig. 2.1).

2.2 Twenty-First Century Skills in Comparison

Using a similar approach adopted by Dede (2009) who took the P21 framework as a baseline for a comparative analysis of various twenty-first century frameworks because of its detailed coverage of skill sets and wide adaptation, we attempt to discern similarities across different frameworks, and put overlapping and identical ideas together so as to provide readers with a convenient way of understanding the core ideas in these frameworks.

In Table 2.1, similar ideas from different frameworks are placed in the same row in accordance with the P21 skill sets. The first common skill set is related to Learning and Innovation skills, which include communication and thinking ability.

Table 2.1 A comparison of twenty-first century skills frameworks in accordance with the P21 skill sets

P21 (skill sets)	OECD (dimensions)	ATCS (categories)
Learning and innovation skills	Communication	Ways of thinking Ways of working
Information, media and technology skills	Information	Tools for working
Life and career skills	Ethics and social impact	Living in the world

The second shared set of skills puts emphasis on the importance of mastery of information technology (IT) skills, which involve both traditional IT skills, such as keyboarding, web surfing, word processing, and information literacy skills (IL), comprising some more advanced use of information such as searching for, evaluating and citing information found on the web appropriately and ethically. The third and last skill mentioned in all the frameworks refers to one's general ability to live and work in the rapidly changing world of the twenty-first century. The skill focuses on the ethical aspect of citizenship, requiring people to take individual, national as well as global responsibility toward the world. It was found that all of three reviewed frameworks considered at some length similar sets of skills and competencies.

2.3 Twenty-First Century Skills in Detail

To take a closer look at what twenty-first century skills entail, Table 2.2 is an adapted version of the P21 framework with the three skill sets and twelve components laid out. While going through the book, readers may refer to Table 2.2 as frequently as needed to review the definition of twenty-first century skills we have employed.

Table 2.2 Capabilities for each set of twenty-first century skills (adapted from P21 2009)

3 skill sets	Learning and innovation	Digital literacies	Life and career skills
12 components	• Core subjects • Critical thinking and problem solving • Communication and collaboration • Creativity and innovation	• Information literacy • Media literacy • Information and communication technology literacy	• Flexibility and adaptability • Initiative and self-direction • Social and cross-cultural interaction • Productivity and accountability • Leadership and responsibility

2.3.1 Skill Set 1: Learning and Innovation

The Learning and Innovation skill set includes four major components covering both knowledge and skills related to learning. "Core subjects" point to the core subject knowledge that is indispensable for all learners in the twenty-first century, which can be vaguely summarized by three "Rs," namely Reading, wRiting, and aRithemetic. The labels of the subjects vary across different continents of the world, but the knowledge covered by them are similar in essence, encompassing knowledge in languages, aesthetics, science, mathematics, humanities, and civics.

In addition to subject knowledge, certain learning skills are deemed particularly imperative in the twenty-first century. These include critical thinking and problem solving skills, communication, and collaboration skills, and creativity and innovation. These soft skills are pivotal for learners to cope with the rapidly changing society in which human connection around the globe and the amount and availability of information are maximized by technological advancement.

2.3.2 Skill Set 2: Digital Literacies

Digital literacies are made up of three key components: information literacy (IL), information and communication technology (ICT) skills, and media literacy (ML). IL is the ability to effectively and ethically select, evaluate, and use information to gain, apply, and share their knowledge (American Association of School Librarians [AASL] 2007). ICT skills, as defined by the International ICT Literacy Panel (2002), refer to the ability to use digital technology, communication tools, and/or networks to access, manage, integrate, evaluate and create bodies of information. The third component, ML, which is interdisciplinary in nature, is associated with the ability to access, analyze, evaluate, and communicate messages in a variety of forms (NAMLE 2012).

In the twenty-first century, online information is readily available. Human life has become more closely connected by the Internet and heavily dependent on digital technologies. More and more classroom activities are now computer-based and capitalize upon the convenience brought about by the World Wide Web. It has therefore become vital for learners to acquire knowledge and skills to harness the power of digital technologies in widening their opportunities for learning, communication, collaboration and knowledge creation (Trilling and Fadel 2009).

In particular, when learners are provided with inquiry learning opportunities, it is important for them to have the IL proficiency needed to gather the information they require for further research actions, which in turn contributes to their successful mastery and construction of knowledge (Todd 2008). Moreover, ICT skills enable learners to utilize technological tools in their learning process. For example, students (especially younger ones) may need skills in using MS Excel and PowerPoint to present their project outcomes. Equally salient is ML, which allows learners to

Table 2.3 Operational definition of the components of digital literacies

Component	Definition	Example
Information literacy (IL)	Ability to recognize when information is needed, and ability to locate, evaluate and use the information effectively and ethically	Searching for information via the Internet or other sources (e.g., books, newspapers, television, YouTube)
Information and communication technology (ICT) skills	Ability to use digital technology, communication tools and/or networks, to access, manage, integrate, evaluate and create information	Using MS Excel to produce charts or histograms from a set of data
Media literacy (ML)	Ability to decode, evaluate, analyze, and produce print and electronic media	Recording and editing a music file

acquire and share information in different media forms (e.g., videos, music, podcasts). The definitions of these components of digital literacies, along with examples, are put together in Table 2.3.

2.3.3 Skill Set 3: Life and Career Skills

Life and career skills help learners cope with complex life and work environments in a knowledge-based and globalized economy. On top of content knowledge and thinking skills, learners are also expected to develop adequate soft skills that equip them with the readiness to adapt to more challenging working environments, manage heavy workload, meet stringent deadlines, as well as interact and work with their counterparts in achieving a mutually agreed goal.

2.4 A Formula of Twenty-First Century Learning

To make the core components of the P21 framework easier to retrieve, Trilling and Fadel (2009) have rearranged and condensed them into seven skills, all beginning with the letter "C" representing **C**ritical Thinking and Problem-solving, **C**reativity and Innovation, **C**ollaboration, Teamwork and Leadership, **C**ross-cultural Understanding, **C**ommunication and Media Fluency, **C**omputing and ICT Fluency, **C**areer and Learning Self-reliance, and three "R" skills referring to **R**eading, w**R**iting and a**R**ithmetic. They have thus summed up twenty-first century learning in the following handy formula:

3Rs × 7Cs = Twenty-First Century Learning	
Reading	**C**ritical Thinking and Problem-solving
w**R**iting	**C**reativity and Innovation
a**R**ithmetic	**C**ollaboration, Teamwork, and Leadership
	Cross-cultural Understanding
	Communication and Media Fluency
	Computing and ICT Fluency
	Career and Learning Self-reliance

Now that we have a common ground on what twenty-first century skills embody, we will examine the education roadmaps of various parts of the world in the next chapter, trying to align the education policies and reforms with the mentioned demands of the twenty-first century. Education systems around the world have been undergoing substantial reforms to ensure the younger generations receive training that enables them to meet the challenges brought about by technological advancements and changes in the global economic structure, and therefore play a more central part in sustaining the development of their society. In the following sections, the education roadmaps in Hong Kong, Switzerland, the U.S., and some other regions are presented to unveil some of the research-supported best practices from different education systems and to highlight lessons we can learn from current education policies worldwide.

2.5 Twenty-First Century Skills and the Education Roadmap in Hong Kong, Switzerland, and the U.S.

Table 2.4 captures the goals of the mentioned education frameworks in Hong Kong, Switzerland, and the U.S., using the P21 framework as a reference point in outlining their differences and similarities. These three places have taken different approaches to twenty-first century skills education. In the subsections that follow, we will discuss the education system of each country/region in greater detail.

2.5.1 Hong Kong

Among all the renowned education systems in Asia, we have chosen to zoom into Hong Kong for a close investigation partly due to its multicultural environment and availability of state-of-the-art technology, and also because the authors of this book have conducted extensive research in the area in relation to the key concepts explored in the chapter. Owing to its century-long colonial history, Hong Kong is one of the most international cities in Asia that combines Western and Eastern cultures in the most harmonious way. As "Asia's World City," the education system of Hong Kong attracts local, Mainland Chinese and overseas students with its

Table 2.4 A summary of the comparison of education roadmaps and P21 standards

P21 twenty-first century skill sets	Components	Hong Kong	Switzerland	The United States		
		EDB seven learning goals	EDK commission report	ISTE standards	AASL standards	Common Core State Standards
Core subjects and twenty-first century themes	English, reading or language arts	✓	✓			✓
	World languages	✓	✓			✓
	Arts	✓	✓			✓
	Mathematics	✓	✓			✓
	Economics	✓				✓
	Science	✓	✓			✓
	Geography	✓	✓			✓
	History	✓	✓			✓
	Government and civics	✓	✓			✓
Learning and innovation skills	Creativity and innovation	✓		✓	✓	
	Critical thinking and problem solving	✓		✓	✓	✓
	Communication and collaboration	✓	✓	✓	✓	✓
Information, media and technology skills	IT literacy	✓	✓	✓	✓	✓
	Information literacy		✓	✓	✓	✓
	Media literacy		✓	✓	✓	✓
Life and career skills	Flexibility and adaptability	✓	✓	✓	✓	✓
	Initiative and self-direction	✓	✓	✓	✓	
	Leadership and responsibility	✓		✓	✓	
	Social and cross-cultural skills		✓		✓	✓
	Productivity and accountability		✓	✓	✓	

world-class institutions, internationally recognized curricula, expertise and quality assurance mechanisms, and rigorous intellectual property protection regime (Education Bureau [EDB] 2011b).

It is stated that the aim of education in Hong Kong is "to promote students' whole-person development and life-long learning capabilities" (EDB 2011a), which essentially aligns with the competencies denoted by twenty-first century skills (P21 2009; Voogt and Pareja Roblin 2010). Tracing back to the beginning of the

twenty-first century, the EDB (2011b) made recommendations to the Hong Kong Government for reforms to be staged in the curricula, assessment mechanisms, and admission systems at different stages of education. These proposed reforms emerged from the foreseeable needs in the changing world of the twenty-first century, with the objective of empowering the younger generation of Hong Kong with "a broad based knowledge, high adaptability, independent thinking and the ability for life-long learning" (EDB 2006, p. 3). Inquiry-based learning was, for the first time, officially introduced in the city's education policies in 2008 (EDB 2008).

Four areas in education have been identified by the Education Commission to be essential skills that students should be able to develop and strengthen during their education, namely moral and civic education, reading to learn, project learning, and information technology for interactive learning. Seven learning goals, which are complementary to these four aspects, have been recognized as 'the overall aim of the curriculum' (EDB 2008) to facilitate the holistic development of students in primary and secondary education. The goals have been set on the basis of a comprehensive approach that focuses on whole-person development and include not only learning skills but personal interest and value enhancement as well. EDB goals may appear on the surface to be distinct from twenty-first century skills. However, the *expectations* of each learning goal are largely coherent with the capabilities associated with the twenty-first century skill sets.

2.5.2 Switzerland

In Switzerland, educational sovereignty resides with the cantons (member states), not with the federal government, so the educational landscape in Switzerland is characterized by the sovereignty of the 26 Cantons and the 4 national languages. Each Canton has its own school curriculum. Back in 2003, a project called harmoS (Harmonisierung der obligatorischen Schule: "harmonization of compulsory school") was launched by the Conference of the Cantonal Directors of Education (EDK). The goal of the project was to establish educational standards and one national curriculum for K12 in Switzerland. The national curriculum is called "Lehrplan 21." At the present moment 15 cantons[1] are willing to harmonize their curriculum. "Lehrplan 21" integrates the national educational objectives (educational standards), thus ensuring compatibility among the cantonal educational systems and responding to the mobility of families within the country, which is becoming an increasing reality (Amsler 2013).

One prominent benefit of the new curriculum is its skills (competence) orientation. "Lehrplan 21" describes the competencies to be attained by the end of compulsory education at the age of 16. The structure is conceptualized in three

[1]A canton is a member state of the federal state of Switzerland. There are a total of 26 Cantons of Switzerland.

cycles, and for each cycle a minimal standard is defined. The rigorous formulation of competencies clearly indicates that the curricular requirements are not likely to be met simply by "covering" the syllabus in a particular subject; students should be competent in the subject matters. Being competent means having the necessary knowledge and being able to apply this knowledge in a particular situation (Amsler 2013). "ICT and Media" has its own place in the curriculum and is integrated into individual subject syllabuses. In "Lehrplan 21," the purpose of "ICT and Media" is to be sure that learners can participate in the media society of today and tomorrow as self-determined, creative, and mature individuals, as well as behave in an appropriate and socially responsible manner. In this area, however, various issues beyond the actual curriculum still need to be resolved, such as framework conditions, jurisdiction, and (basic and further) teacher training (Amsler 2013).

Another initiative led by the Swiss Academy of Engineering Sciences targets new technologies and educational trendspotting (SATW) (Jobin and Morel 2012). SATW is recognized as the principal organization for the communication of independent, objective, and comprehensive information about technology—as a basis for the forming of well-founded opinions—and as an effective institution for the promotion of engineering sciences and new technologies in Switzerland.

Based on the key competences for lifelong learning proposed by the Recommendation 2006/992/EC of European Parliament (Europa 2006), SATW proposed a matrix of transversal competencies such as collaboration, communication, learning strategies, creative thinking, and self-reflexive methods to be applied in general education consisting of the media and ICT, health, learning in projects, democracy, society and environment, and a specific subject-based education in the following school subjects: Languages, mathematics and science, social sciences, arts, and sports.

2.5.3 The U.S.

The U.S. Bureau of Labor Statistics forecasts that the number of jobs in professional computing and information sciences is expected to grow at more than twice the rate of that of all positions in engineering, life sciences, natural sciences, and physical sciences by 2018 (Lacey and Wright 2009). More broadly, technology has become commonplace in U.S. workplaces and the professional sphere. Survey data from Pew Research in late 2013 shows that among a randomized sample of U.S. jobholders, 94 % use the Internet at work, representing all kinds of enterprises from technology companies to non-technology firms, from big corporations to small proprietor operations, and from those in urban areas, farms, and places in between (Purcell and Rainie 2014). Furthermore, many jobs require specialized uses of computing software, productivity tools and web services, and more and more computers are deployed to control and operate technical equipment, tools and machinery. Government officials, policy makers, education leaders, and scholars alike agree that in the midst of this global transition to a knowledge-driven

economy, there is a need for young people to be more adequately prepared during their public schooling for the use of technology. The authors of this book all share the same view. Education must extend students' learning in schools beyond reading to include inquiry, discovery, critical thinking, productivity, and innovative creation with technology, to support students' information-to-knowledge journey, and their personal, social and cultural growth as well as livelihood (AASL 2007; International Society for Technology in Education [ISTE] 2007; National Education Technology Plan [NETP] 2010).

Like many other nations, the education system of the U.S. is in many ways driven by testing requirements. Under the "No Child Left Behind" (NCLB) Act in the U.S., public education is universally available, with control and funding coming from the state, local, and federal government. Public school curricula, funding, teaching, employment, and other policies are set through locally elected school boards, who have jurisdiction over individual school districts. State governments set educational standards and mandate standardized tests for public school systems. NCLB places an emphasis on test-based assessment and school/teacher accountability within the traditional U.S. core curricular domains of math, science, English/language arts, and social studies. These testing imperatives underscore school improvement efforts, and increasingly, curriculum and day-to-day classroom pedagogy. As of late Fall 2015, NCLB was replaced by the Every Student Succeeds Act (ESSA), a new law the U.S. president Barack Obama is expected to sign into legislation. This Act shifts the fight for the survival of public education and the teaching profession to the U.S. states. States will now have wide discretion in goals and objectives, accountability, performance measurement, and handling intervention in low-performing schools. Tests will play a central role, but states will be charged with identifying other factors prioritized for learning, tailored to the localized population.

The Common Core State Standards initiative has invigorated the national discussion around curriculum reforms, and 47 states and the District of Columbia have signed on. These new national level standards include anchors for digital and information skills. To go further, the National Education Technology Plan of 2010 offers a siren call for advances in student-centered, personalized learning experiences leveraging technology affordances for teaching, learning, and administration. The Plan also calls for greater research, development, and commercialization of effective innovations to maximize learning experiences for youth (in the traditional subject domains, and, in domains not currently prioritized by the traditional canon, such as computer science/computational thinking). The Plan is worthy of investigation as it offers a roadmap for quite sweeping reforms, and was drafted by a number of innovators in education research, including several whose work is situated in the more newly emergent research discipline of the "learning sciences."

There are several notable standards frameworks that address twenty-first century skills in the U.S. The Common Core State Standards (CCSS) framework reflects the national level core curriculum in the U.S. in the subject domains of English

Language Arts/Literacy (ELAL) and mathematics. The CCSS standards attach considerable importance to the application of higher order thinking skills integrated with a range of technology tools for the development of rigorous knowledge and its application to solving world problems (CCSS 2010). Its Reading, Writing, and Research standards require that students comprehend, evaluate, and present increasingly complex information, ideas, and evidence through reading, listening, and speaking as well as through engagement with information technology and media in all its forms (CCSS 2010). Two other associations, the International Society for Technology in Education (ISTE) and American Association of School Librarians (AASL), issued standards in 2007 for digital and information literacies, which include outcomes specifically related to creative technology uses and dispositions for productivity with technology tools (ISTE 2007; AASL 2007).

2.6 The Need for an Inquiry-Based Pedagogical Approach

In the beginning of the chapter, a comparison of various twenty-first skills frameworks indicated that they vary across international contexts but, on the whole, present commonalities that can be cross-referenced. We then highlighted a prominent model for twenty-first century skills developed in the U.S. (namely, P21 etc.) and used this framework as an anchor to juxtapose skill dimensions that have been developed and disseminated as learning goals in other international contexts. In 2.4, we discussed educational reforms in Hong Kong, Switzerland, and the U.S. Reforms in all three places make reference to twenty-first century skills, although under different models or frameworks. It would thus be appropriate to say that policy makers generally recognize the importance of such skills in one's learning process and in the workplace.

One limitation of the twenty-first century skills models is that while they specify prioritized learning objectives, they do not offer educators the "means" by which to achieve those articulated "ends." School leaders, teachers, and decision-makers need to better understand "what works." UNESCO is undertaking regional projects to assess transversal skills (UNESCO 2015). This shows the relevancy of supporting schools. Education research and scholarly publications in each of the countries and regions discussed as well as internationally support these efforts, but often lack coordination and dissemination of findings from one region to the next, across disciplines, hinders progress. This book aims to synthesize some of the literature on technology-based inquiry pedagogical approaches, with a pragmatic focus on implementation studies. Students acquire twenty-first century skills throughout the inquiry process, guided by teachers along the way (Kuhlthau et al. 2007, 2015). In Chaps. 3–5, we present empirical results from several implementation studies, and showcase the best practices for twenty-first century skills education that emerge, examining the results and limitations of each case.

References

American Association of School Librarians [AASL]. (2007). *Standards for the 21st–Century learner*. Retrieved May 11, 2015 from http://www.ala.org/aasl/standards

Amsler, C. (2013). *'Lehrplan 21'—politics and history. In: Public history weekly 1*. Retrieved May 11, 2015 from http://public-history-weekly.oldenbourg-verlag.de/1-2013-9/lehrplan-21-politics-and-history/

Ananiadou, K. & Claro, M. (2009). *21st century skills and competences for new millennium learners in OECD countries*. *OECD education working papers, No. 41*, OECD Publishing. Retrieved May 11, 2015 from http://www.oecd-ilibrary.org/education/21st-century-skills-and-competences-for-new-millennium-learners-in-oecd-countries_218525261154

Berry, B. (2010). The teachers of 2030: *Creating a student-centered profession for the 21st century*. MetLife Foundation. Retrieved May 11, 2015 from http://www.bcpsea.bc.ca/documents/research_articles/TS2030.pdf

Black, R. (2009). English-language learners, fan communities, and 21st-century skills. *Journal of Adolescent & Adult Literacy, 52*(8), 688–697.

Castells, M. (2005). The network society: From knowledge to policy. In M. Castells & G. Cardoso. (Eds.), *The network society: from knowledge to policy*. Washington, DC: Johns Hopkins University. Retrieved May 11, 2015 from http://www.umass.edu/digitalcenter/research/pdfs/JF_NetworkSociety.pdf.

Castells, M. (2010). *The rise of the network society. The Information age: Economy, society, and culture* (2nd ed., Vol. 1). Oxford, UK: Wiley-Blackwell.

CCSS. (2010). *Common core state standards initiative*. Retrieved May 6, 2015 from http://www.corestandards.org/the-standards

Dede, C. (2009). *Comparing frameworks for 21st century skills*. Retrieved May 11, 2015 from http://watertown.k12.ma.us/dept/ed_tech/research/pdf/ChrisDede.pdf

Delors, J. et al. (1996) *Learning: The treasure within*. UNESCO. Paris: UNESCO. Retrieved May 11, 2015 from http://unesdoc.unesco.org/images/0010/001095/109590eo.pdf

Dunning, J. H. (2000). Regions, globalization, and the knowledge economy: Issues stated. In J. H. Dunning (Ed.), *Regions, globalization, and the knowledge-based economy* (pp. 7–41). Oxford: Oxford University Press.

Education Bureau [EDB]. (2006). *Progress report on the education reform (4)*. Retrieved May 11, 2015 from http://www.e-c.edu.hk/eng/reform/Progress%20Report%20(Eng)%202006.pdf

Education Bureau. (2008). *Midterm report on education reform to school heads and teachers*. Retrieved May 11, 2015 from http://www.edb.gov.hk/attachment/en/curriculum-development/7-learning-goals/about-7-learning-goals/english_professional_report_final_v3.pdf

Education Bureau. (2011a). *EDB—welcome message*. Retrieved May 11, 2015 from http://www.edb.gov.hk/en/about-edb/info/welcome/

Education Bureau. (2011b). *Report on the development of education services in Hong Kong*. Retrieved May 11, 2015 from http://www.e-c.edu.hk/eng/online/annex/Report%20Dev%20Edu%20Service%20Eng.pdf

Enright, M. J. (2000). Globalization, regionalization, and the knowledge-based economy in Hong Kong. In J. H. Dunning (Ed.), *Regions, globalization, and the knowledge-based economy* (pp. 381–406). Oxford: Oxford University Press.

Europa (2006). *Recommendation 2006/962/EC of the European Parliament and of the Council of 18 December 2006 on key competences for lifelong learning*. Retrieved May 11, 2015 from http://europa.eu/legislation_summaries/education_training_youth/lifelong_learning/c11090_en.htm

Griffin, P., McGaw, B., & Care, E. (2012). *Assessment and teaching of 21st century skills*. Dprdrecht: Springer.

International ICT Literacy Panel (2002). *Digital transformation: A framework for ICT literacy (A report of the International ICT Literacy Panel)*. Princeton, NJ: Educational Testing Service.

Retrieved Dec 18, 2015 from https://www.ets.org/Media/Tests/Information_and_Communication_Technology_Literacy/ictreport.pdf
International Society for Technology in Education (ISTE). (2007). NETS for students 2007. http://www.iste.org/standards/nets-for-students.aspx
Jobin, J.F., & Morel, R. (2012). Neue Technologien und Educational Trendspotting. SATW INFO 1/12, March 2012. Retrieved May 11, 2015 from http://www.satw.ch/publikationen/satwinfo/Educational_Trendspotting_DE.pdf
Kozma, R. B. (2008). *ICT, education reform, and economic growth: A conceptual framework. Intel. White Paper.* Retrieved May 11, 2015 from http://download.intel.com/education/HP/Kozma_WP1.pdf
Kuhlthau, C., Maniotes, L., & Caspari, A. (2007). *Guided Inquiry: Learning in the twenty-first century*. Westport, CT: Libraries Unlimited.
Kuhlthau, C., Maniotes, L., & Caspari, A. (2015). *Guided inquiry: Learning in the twenty-first century* (2nd ed.). Westport, CT: Libraries Unlimited.
Lacey, T. A., & Wright, B. (2009). Occupational employment projections to 2018. *Monthly Labor Review, 123*(11), 82–123.
Levy, F., & Murnane, R. J. (2004). *The new division of labor: How computers are creating the next job market*. Princeton, NJ: Russell Sage Foundation.
Medel-Añonuevo, C., Ohsako, T. & Mauch, W. (2001). *Revisiting lifelong learning. UNESCO institute for education.* Retrieved May 11, 2015 from http://www.unesco.org/education/uie/pdf/revisitingLLL.pdf
Ministry of Education-Singapore. (2010a). *MOE to enhance learning of 21st century competencies and strengthen art, music and physical education. Press releases*. Retrieved May 11, 2015 from http://www.moe.gov.sg/media/press/2010/03/moe-to-enhance-learning-of-21s.php
National Association for Media Literacy Education [NAMLE]. (2012). *Media literacy defined*. Available at: http://namle.net/publications/media-literacy-definitions/. Accessed November 19, 2015.
National Education Technology Plan (NETP). (2010). *Transforming American education: Learning powered by technology.* USA. Department of Education.
OECD. (2004). *Lifelong learning*. OECD Policy Brief. Paris: OECD.
OECD (2005). *The definition and selection of key competencies: Executive summary.* Paris, France: OECD. Retrieved April 22, 2015 from http://www.oecd.org/pisa/35070367.pdf
Partnership for 21st Century Skills [P21]. (2009). *P21 framework definitions.* Retrieved May 11, 2015 from http://p21.org/storage/documents/P21_Framework_Definitions.pdf
Pedró, F. (2006). *The new millennium learners: Challenging our views on ICT and learning, OECD-CERI.* Retrieved May 11, 2015 from http://www.oecd.org/edu/ceri/38358359.pdf
Pigozzi, M. J. (2006). A UNESCO view of global citizenship education. *Educational Review, 58* (1), 1–4.
Purcell, K., & Rainie, L. (2014). *Technology's impact on workers*. A report of the Pew Internet and American Life Project. Retrieved May 11, 2015 from http://www.pewinternet.org/2014/12/30/technologys-impact-on-workers/
Rotherham, A., & Willingham, D. (2009). 21st century skills: The challenges ahead. *Educational Leadership, 67*(1), 16–21.
Silva, E. (2009). Measuring skills for 21st-century learning. *The Phi Delta Kappan, 90*(9), 630–634.
SKBF (2006). Bildungsbericht Schweiz 2006 [Education report Switzerland 2006]. Aarau: SKBF.
Todd, R. J. (2008). Youth and their virtual networked worlds: Research findings and implications for school libraries. *School Libraries Worldwide, 14*(2), 19–34.
Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times*. San Francisco, CA: Jossey-Bass.
UNESCO. (2003). *From the information society to knowledge societies.* Retrieved May 11, 2015 from http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/CI/CI/pdf/wsis_geneva_prep_background_paper.pdf

UNESCO. (2012). *Competencies. Education.* Retrieved May 11, 2015 from http://www.unesco.org/new/en/education/themes/strengthening-education-systems/quality-framework/desired-outcomes/competencie/

UNESCO. (2015). *Transversal competencies in education policy & practice*. Bangkok: UNESCO Bangkok Office. Retrieved January 19, 2016 from http://unesdoc.unesco.org/images/0023/002319/231907E.pdf

Voogt, J., & Pareja Roblin, N. (2010). *21st century skills—discussion paper.* Enschede, The Netherlands: University of Twente. Retrieved May 11, 2015 from http://www.voced.edu.au/content/ngv56611.

Part II
Twenty-First Century Skills Education: Plagiarism-Free Inquiry PjBL in Asia, Europe and North America

Chapter 3
Twenty-First Century Skills Education in Hong Kong and Shenzhen, China: Inquiry Project-Based and Collaborative Teaching/Learning Supported by Wiki

Part One of this book gave us an overview of twenty-first century skills education. We introduced various models of twenty-first century skills, in particular the P21 (2009) framework that comprises three skill sets in the aspects of learning and innovation, digital literacies, and life and career skills—the appropriate skills that students in the present day should acquire through education. We established that such skills are essential given the challenges brought about by technological advances and changes in the global economic structure, and that education reforms are underway in countries around the world to meet these challenges. We therefore devote Part Two (Chaps. 3–5) to case studies of applying technology-based pedagogies to equip students with skills for the modern world. Our first stop in Asia sees the application of Wiki-supported and collaboratively taught inquiry project-based learning in Hong Kong and Shenzhen, China. In Chap. 4 we visit Europe, where Science Education in Switzerland is conducted through project-based learning using Wiki. In Chap. 5 we travel across the Atlantic Ocean to North America, in which inquiry-based game design learning approach is adopted. With these case studies across the three continents, we hope to present research-supported evidence that technology-based pedagogies indeed foster the development of twenty-first century skills better than traditional didactic approaches to teaching.

In the twenty-first century, critical thinking and self-directed learning are valued as much as the acquisition of knowledge in one's learning experience. With regard to the first two learning goals, traditional didactic approaches to teaching and learning is often criticized for being a stifle to learners' development of deep thinking as well as their ability to apply knowledge and reasoning skills. At the same time, the constructivist approach is generally advocated by educators to be more powerful in facilitating learning (Kuhlthau et al. 2007, 2015; Zmuda and Harada 2008). With the pro-constructivist approach is the increasing adoption of inquiry group project-based learning (PjBL) and the use of social media in classrooms, in which students are required to take substantial responsibility in their own

S.K.W. Chu et al., *21st Century Skills Development Through Inquiry-Based Learning*, DOI 10.1007/978-981-10-2481-8_3

inquiry learning process (Harada and Yoshina 2004a, b; Chu et al. 2007; Kuhlthau et al. 2007, 2015; Harada et al. 2008). In this chapter we will discuss the process of conducting inquiry group PjBL and discuss the merits of this approach as a collaborative teaching and learning approach for twenty-first century skills education. This chapter will begin with a review of approaches to twenty-first century skills education proposed and piloted by researchers worldwide. We will then present, based on the experience of the authors, four case studies of collaborative teaching and learning with inquiry group PjBL in Hong Kong and Shenzhen.

3.1 Collaborative Approaches to Conducting Inquiry Group Project-Based Learning

Inquiry-based learning takes various forms in terms of its administration, setup, and learning outcomes. Inquiry-based learning (IBL) is a learner-centered approach that uses questioning to actively engage students in their own learning (Harada and Yoshina 2004a; Chu et al. 2007; Kuhlthau et al. 2007, 2015). Related studies have shown that IBL, compared to traditional didactic teaching, is more effective in promoting students' ability to apply knowledge, deep thinking, and reasoning skills (Harada and Yoshina 2004b; Kuhlthau et al. 2007, 2015). IBL can be successfully conducted in schools with the help of group projects (Chu 2009; Chu et al. 2011a). With the project-based learning (PjBL) approach, students carry out in-depth exploration of issues, themes, or problems in-depth without pre-defined answers (Harada et al. 2008). This opens up opportunities for them to engage in thought-provoking and realistic learning processes (David 2008). With these advantages of IBL and PjBL over traditional didactic teaching (Hmelo-Silver et al. 2007; Gallagher and Gallagher 2013), integrating IBL and PjBL in student group work has been tried out with equally positive results (Krajcik et al. 1998; Chu 2009; Chu et al. 2011a, b, 2012a; Du et al. in press). As the discussion continues, we refer to such an approach as inquiry group PjBL.

Education institutions require the collaborative effort of all stakeholders on top of the expertise and dedication of individual teaching staff so as to maximize teaching and learning outcomes and effectiveness. Lesson co-preparation and collaborative teaching are not a rare sight in today's school operation, though challenges at various levels of teacher collaboration do exist (Vangrieken et al. 2015). A collaborative school culture has been acknowledged to powerfully improve students' understanding and achievements in reading ability, language, and STEM (science, technology, engineering, and mathematics) subjects (Harada and Yoshina 2004a, 2010; Goddard et al. 2007; Kuhlthau et al. 2007, 2015; Lomos et al. 2011). In the following section, international initiatives in three different forms of collaborative teaching are introduced: (1) team-teaching amongst school teachers, (2) school teachers–school librarian collaboration, and (3) collaboration among school administrators, school teachers, and parents.

3.1.1 Team-Teaching Amongst School Teachers

Team-teaching has been widely adopted in language and humanities education in many countries. In the U.S., the enrollment of large numbers of English Language Learners (ELL) in K-12 schools has called for a high degree of collaborative input between subject teachers and English as a Second Language Teachers (ESLT) to help the students integrate themselves into mainstream schooling (Pawan and Ortloff 2011). Team-teaching among teachers with different nationalities and cultural backgrounds has been popular for language learning from primary to tertiary levels. In Germany, a team-taught, project-based learning program involved both Native English Teachers (NET) and Local English Teachers (LET) in giving instructions in German and English simultaneously (Pardy 2004). Participating students enjoyed the lessons, and were able to switch between two languages smoothly. Teachers who took part in the study reflected that lesson effectiveness improved with equal participation from both NETs and LETs from the initial planning phase. Similarly in Hong Kong, it is common practice for primary and secondary school students who are team-taught by NET and LET. NETs serve to boost students' motivation to practice oral English, and LETs focus on the Hong Kong school syllabus and examination requirements (Carless 2006; Carless and Walker 2006; Sung 2014). Cases of team-taught language programs were also documented in Taiwan primary schools (Luo 2007, 2014; Islam 2011) but with varying degrees of success—Taiwan students agreed on the value of team-teaching for language learning but they reported that it was less effective in helping them overcome their fear of using English to communicate.

Collaborative teaching has been detailed in the domain of Arts education as well, often as an interdisciplinary project including one art form with another. An example of connecting multiple art subjects is found in Singaporean secondary schools, where a module of instruction was implemented combining different art forms namely, dance, music, drama, and visual arts (Bautista et al. 2015). The project aimed to guide students in discovering intersections among different art forms and to encourage them to create and try new forms of artistic expression. Three participating teachers connected and discussed with students the various art forms under the organizing theme of "space." The collaboration enabled students to appreciate and deconstruct artistic productions in each art form, and understand the convergence and divergence among them. They were also able to develop a broader perspective, analysis, and expression of art.

3.1.2 Collaboration Between Subject Teacher and School Librarian

The growing involvement of librarians in collaborative teaching across different educational settings, characterized by partnerships between librarians and subject

teachers, has been described by a number of researchers (Konzal 2001; Mokhtar and Majid 2006; Montiel-Overall 2008). Librarians have now taken a more prominent role in promoting Information literacy (IL) within the context of the regular curricula, and in leading technology integration to ensure that students are equipped with the necessary skills to utilize digital resources in learning (Johnston 2012). Professional guidelines for librarians have evolved such that collaborative work with teachers could be more conducive to the development of students' IL proficiency (AASL 2007). While teacher–librarian collaboration has been noted in tertiary education (Mackey and Jacobson 2005), few studies specifically investigated the practice of teacher–librarian collaboration in elementary schools. Section 3.2 of the chapter will outline studies conducted by the first author of the book which examined the impact of teacher–librarian collaborative teaching in promoting twenty-first century skills for primary students in Hong Kong.

3.1.3 School Administration–Subject Teachers–Parents Collaboration

A collaborative teaching team for inquiry group PjBL may be made up of school administrators and parents as collaborators. In promoting inquiry learning, researchers and teachers with the expertise can provide input and motivation for teachers and students less familiar with PjBL. The school principal and curriculum leader(s) can offer administrative support to enhance overall effectiveness when carrying out the new teaching initiative (Chen 2008). Parents' involvement has also been found to positively influence academic as well as personal development learning outcomes (Lee and Bowen 2006; Seginer and Vermulst 2002), hence their role is valuable for students participating in inquiry learning. A study in Hong Kong demonstrated how teachers from different subject areas (General Studies (GS), Chinese Language, Information Technology) and the school librarian collaborated when conducting inquiry group PjBL among primary four students aged 9–10. The parents' duty was to facilitate their children's completion of the project, but they were urged to provide assistance only when needed. Project findings showed that students' ability to learn independently was strengthen with some parental intervention (Chu 2009; Chu et al. 2011a).

It is important that the school maintains close contact with parents. Home–school communication on elementary students' progress and behavior at school has been traditionally mediated via student handbooks, phone calls and face-to-face meetings. This is often found to be time-consuming and lack efficiency. An integrated online platform named the E-Home book system (EHS) which was introduced in Taiwan to facilitate communication among parents, students, and teachers (Chen et al. 2007), with functions that allowed teachers to share teaching materials and post updates, and provided space for discussion among parents, students, and teachers. Similarly in Thailand, social media technology is used to foster teacher–parent collaboration

(Liou 2011). School teachers managed and moderated a class website created on Google Sites, where teachers, parents, and students can view and leave comments. The contents contained students' in-class progress updates, information on textbooks, class policy, syllabus, homework, assessment results, and messages from teachers to parents.

3.2 Using Social Media Technology to Facilitate Collaborative Writing

In recent years, social media has been regarded as a new means of establishing online communication. Social media has speedily burgeoned during the last decade (Leadbeater 2009) and its use has become the norm (Casey 2013). With rapid technological advancement and the present generation being described as digital natives in the twenty-first century (Cheese 2008), education has been remodeled to integrate social media technologies (e.g., blogs, wikis) to facilitate teaching and learning (Richardson 2006; Chu and Kennedy 2011). In the following sections, we review a number of studies that explore the application of various forms of social media technology in nurturing twenty-first century skills among learners at the primary, secondary, and tertiary levels. Online collaborative tools serve dual purposes: content development as well as space for discussion and co-construction of knowledge amongst group members working together. Collaborative writing platforms may be sorted broadly into two main categories: ones that do not require installation, such as Wikibook, Google Sites, PBworks and Google Docs, and others that need to be installed, such as TWiki and MediaWiki (Liang et al. 2009).

3.2.1 Wiki

Wiki is one of the more popular forms of social media technology and is portrayed as "a collaborative web space where anyone can add content and anyone can edit content that has already been published" (Richardson 2006, p. 8). Through the exchange of ideas or peer comments on wiki, students have been observed to be able to give constructive feedback on the content and language use of their shared work (Mak and Coniam 2008). Studies on the application of wiki at different levels and in domains of education—primary, secondary, and tertiary across different subject areas including Chinese, English, GS, Geography, Science, Knowledge Management, and Information Management—have confirmed its positive impact on students at large (e.g., Tavares and Chu 2012; Woo et al. 2011). Projects conducted using wiki promoted collaboration, enhancement of work quality (Chu 2008; Thomas et al. 2009; Wong et al. 2011), and development of social skills in the course of negotiation (Lee 2010; Fung et al. 2011). Wiki is also effective in

improving students' self-efficacy through online discussions, as reported by participating students in Avci and Askar (2012).

3.2.2 *Google Docs*

Google Docs is an online, Microsoft Office-like interface that enables multiple users to easily edit and share documents. Elementary school students in Taiwan who participated in a collaborative, journalistic research project on Google Docs reported that the project significantly enhanced learning outcomes in terms of their participation, sharing of responsibilities, interaction quality, and task execution (Shen and Wu 2011). This platform for collaboration is often compared to other forms of social media or text-editing tools in terms of its usability and effectiveness. On one hand, students in Hong Kong claimed that they felt more comfortable using Google Docs than Wikis, as the former has a similar interface to their usual word editing software Microsoft Word, whereas the latter requires setting up and knowledge on programming language for construction (Chu and Kennedy 2011). On the other hand, wiki is more efficient in supporting collaboration (Chu and Kennedy 2011). Google Docs' contribution to efficiency might be limited to early phases of coworking when exchanges of preliminary ideas are involved; advanced project work were still felt to require face-to-face discussions via conference calls, internet video meeting, or participants physically working together (Rimor et al. 2010).

In Sects. 3.1 and 3.2, we have discussed approaches and tools used in collaborative teaching and learning in different contexts around the world with examples in team-teaching, teacher–librarian collaboration, school–teacher–parent collaboration as well as the use of social media platforms of wiki and Google Docs. In the next section, we will present four cases on collaborative teaching and learning facilitated by social media in primary and secondary schools in Hong Kong and Mainland China.

3.3 Case Studies on Collaborative Teaching and Learning of Twenty-First Century Skills

Inquiry group PjBL is seen as a promising pedagogy in the twenty-first century, yet there are numerous challenges as witnessed from its implementation in schools. Such difficulties include the lack of time for lesson planning and teaching, lack of manpower to cope with the extra workload for teachers, the lack of teaching experience, skills and knowledge, and the lack of motivation in teachers (Edelson et al. 1999). Without adequate support and training for teachers, conducting inquiry group PjBL in classrooms may not necessarily be conducive to quality teaching and

Table 3.1 A brief summary of four case studies

Cases	Context	Assessment	Outcomes	References
Case 1	Inquiry group PjBL collaboratively taught by the subject teachers of GS, Chinese language and ICT, and the school librarian to primary 4 (P.4) students (aged 9–10) in a school	Project grades and self-report questionnaire data were used to measure the learning outcomes. The PIRLS standard reading test was administered to measure students' reading attitude (SATR) and reading self-concept (SRSC)	• Collaboratively taught projects yielded higher quality work from students than traditional projects taught by one teacher • Questionnaire outcomes revealed that students, parents, and teachers recognized improvement in the relevant twenty-first century skills • Students' overall reading performance in informative texts and literary texts improved significantly. In particular, students with average and highly positive attitudes and those with high self-efficacy in reading displayed positive changes	Chu (2009), Chu et al. (2011b)
Case 2	A refinement of the collaborative teaching approach used in Case 1 with P.4–5 students (aged 9–11) from four schools; use wiki for collaborative writing with P.5 students	An online survey examining the four factors of learning/pedagogy, motivation, group interaction, and technology was also administered	Students had positive perceptions (scores above 3.0 out of 5) regarding the effects of using wiki as a collaborative learning tool for English writing, on all the four aspects of learning	Chu et al. (2011c), Tavares and Chu (2012)

(continued)

Table 3.1 (continued)

Cases	Context	Assessment	Outcomes	References
Case 3	Using Wiki to facilitate group writing in a language course in Shenzhen, China for grade 4 students (average age 10)	Student perceptions were measured using a questionnaire with 21 items on motivation, interaction, the teacher's role, audience, and technology	Students' writing performance improved after writing using the wiki-based platform. They also perceived higher personal motivation and writing ability, and enhanced computer and collaborative skills. Benefits in group interaction and subject knowledge were detected too	Li et al. (2012)
Case 4	Collaborative learning in inquiry group PjBL with wiki to develop IL skills and awareness of plagiarism among secondary 1 and 2 students (aged 12–13 and 13–14) in a school	• The effect of IL skills was measured using the Tools for Real-time Assessment of Information Literacy Skills (TRAILS) • A plagiarism index generated from the online 'Small SEO Tools' and a plagiarism assessment scale were also used	• The students performed best in identifying potential sources; their performance was moderate in developing, using and revising search strategies, evaluating sources and information, and developing a topic • A refined strategy—the UPCC pedagogy—was successful in reducing plagiarism behavior	Chu et al. (2012a, b, c), Yeung et al. (2012), Siu et al. (2014), Chu (2016), Yeung et al. (in press)

learning. In this section, we introduce case studies that illustrate the use of collaborative teaching and social media technology in conjunction with inquiry group PjBL, and we synthesize the findings of previous research projects carried out in primary and secondary schools in Hong Kong and Mainland China to underscore the context, assessment methods, and outcomes of each study. The case studies are outlined in Table 3.1.

3.3.1 Case 1: Empirical Evidence for Collaborative Teaching in Inquiry Group PjBL (Chu 2009)

In case 1, researchers and school educators devised an inquiry project-based learning (PjBL) model, in which the school principal, experts in inquiry group PjBL, GS teachers, the school librarian, Chinese teachers, ICT teachers, and parents came together to form an 'extended team' in guiding students through their inquiry projects. The study aimed to identify the factors that contributed to effective collaboration in the extended team. Another goal of the study was to investigate the impact of collaborative teaching on promoting children's attainment, which was measured by their performance in the eight major dimensions of twenty-first century skills: IL, reading ability, writing ability, IT skills, subject knowledge, social and communication skills, presentation skills, and research skills. Results showed that the collaborative teaching approach equipped students with the necessary skills and abilities to conduct inquiry group project work.

A total of 142 Primary 4 students (aged 9–10), 10 subject teachers, and a school librarian in School A took part in the study. In 2 phases, students completed 2 GS projects on their topics of interest relevant to the curriculum-based themes. Prior to the study, GS projects had been implemented under the sole supervision of GS teachers. In the case study, each participating subject teacher contributed their expertise to help students in specific areas through different steps, e.g., developing research questions, searching for and using information sources, analyzing and interpreting the results, etc. (see Fig. 3.1). GS teachers assumed the role of facilitators of learning, allowing students the freedom to develop their project topics, and played a part in enriching students' domain-specific knowledge. In the process of searching for information, students were supported by librarians who taught them how to use information databases and search engines effectively. This echoes with the important role of librarians highlighted by Harada and Yoshina (2010) that librarians can support teachers by guiding students in developing their IL skills, enabling students to better evaluate, and interpret relevant information. The composition of the teaching team is adapted based on the guided inquiry design process put forward by Kuhlthau et al. (2007), who recommend that optimum collaboration can be made possible with a flexible three-member team within a school context consisting of two subject teachers and one librarian who join hands in offering students guidance in their inquiry learning projects. Some of these steps, and the contributions of collaborating teachers may overlap, depending on the agreed schedule for achieving the learning objectives.

A post-intervention questionnaire administered asking for participants' self-report on perceived effectiveness found that teachers, parents, and students all gave comparable ratings affirming improvements felt in the eight dimensions of learning. Students acknowledged improvement in their information literacy, social and communication skills, and presentation skills among other dimensions of learning (see Table 3.2). Students also noted various contributions of the

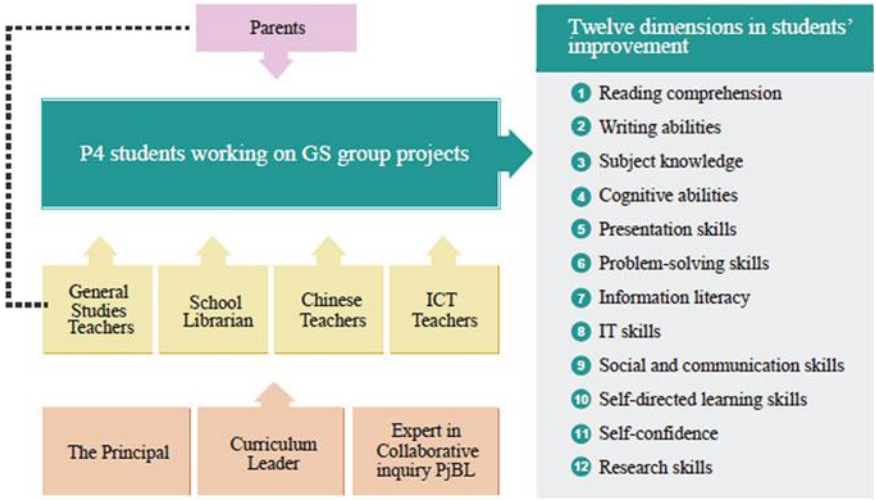

Fig. 3.1 Inquiry group PjBL collaborative teaching model (reproduced from Chu et al. 2012b) (This figure shows a refined inquiry group PjBL collaborative teaching model. The following four dimensions in students' improvement were not investigated in the studies discussed in Sect. 3.3.1: cognitive abilities, problem solving skills, self-directed learning skills, and self-confidence. Student improved in these four dimensions as well)

Table 3.2 Participants' perceptions of the benefits of the learning dimensions from the inquiry group PjBL experience (adapted from Chu 2009)

Dimension of learning	Teaching staff (n = 11)	Parents (n = 27)	Students (n = 142)
Information literacy	4.00 (0.63)	3.74 (0.68)	3.60 (1.12)
Reading ability	3.91 (0.30)	3.26 (0.99)	3.48 (1.07)
Writing ability	3.73 (0.65)	3.18 (1.07)	3.48 (1.11)
IT skills	3.82 (0.60)	3.37 (1.02)	3.28 (1.21)
Subject knowledge	4.18 (0.75)	3.60 (0.96)	3.88 (1.05)
Social and communication skills	3.82 (0.75)	3.40 (0.83)	3.72 (1.1)
Presentation skills	4.00 (0.82)	n/a	3.40 (1.13)
Research skills	3.50 (1.14)	n/a	3.60 (0.52)

Note The respondents rated the influence of inquiry group PjBL on the different dimensions of learning in a scale of 1–5 where 1 refers to *none* and 5 *a lot* (Chu 2009)

collaborating teachers in their completion of the projects, and especially valued the help of the school librarian, rating the librarian's helpfulness 4.29 (mean) out of 5.

The GS teachers assessed students' projects. The project grades of students who received collaborative teaching intervention in their inquiry group PjBL learning were juxtaposed with those of the students who completed the task under the traditional approach where project work was led by only the GS teacher without

other teachers' involvement. Findings suggest that students who experienced inquiry group PjBL were able to progress from simple searching tasks to a more investigative process of understanding learned facts. The efficacy of such an approach was also evident in the higher quality of the output of the inquiry group PjBL project, compared to groups that were exposed to traditional approaches. Parents observed that their children's engagement in inquiry group PjBL allowed the students to "[learn] to communicate with [their] classmates," while others reported that the students spontaneously shared more information and experiences with their parents, which in turn promoted better parent–child communication and relationships. Other investigations of the inquiry group PjBL approach found related improvement in students' IL skills (Chu et al. 2011a), and enhanced reading abilities and reading interests (Chu et al. 2011b). These noticeable gains from inquiry group PjBL were relevant to twenty-first century skills. Teachers who participated in the collaborative process also felt that they had more opportunities to communicate with their colleagues. A teacher proclaimed that collaboration resulted in "some positive effects on curriculum development and integration between subjects as [they] reduced the overlapping topics, which improved teaching efficiency" (Chu 2009, p. 1677). The teachers also noted other positive aspects of collaborative teaching including integration of subject areas, which facilitated their students' knowledge acquisition and widened the possibilities of their choice of effective teaching strategies.

Teachers overall attributed the positive project results to the collective effort of all the participating teachers, who were willing to sacrifice their time and cooperate. Throughout various stages of project implementation, the teaching staff held informal discussions. As the students' group projects were part of the GS curriculum, the GS teacher served as the cornerstone and the point of communication among team members. GS teachers and Chinese language teachers met frequently as some weekly Chinese assignments were closely related to the group projects. The teachers met to monitor students' progress as students become more and more familiar with potential project topics. There were also frequent discussions between GS teachers and librarians, during which they identified what the librarian could teach students to equip them with the necessary IL skills to carry out their group projects. Interactions with the IT teacher were less frequent after initial formal meetings with all stakeholders, as the IT curriculum was revised to align with the expected learning outcomes of the inquiry PjBL assignments.

The project was not without its limitations—factors that delay the progress or affect the success of the implementation (Kuhlthau et al. 2007). One of the obstacles is parents' concern over the students' workload. To prevent parents from intervening in the projects, the grades of the two inquiry PjBL projects would not influence students' final subject grades. While parents did acknowledge that the projects effectively improved their children's 8 dimensions of learning, they worried that the projects increased their children's workload. Some parents were of the view that unless the school reduced the amount of regular homework to offset the time and effort students needed to spend on the inquiry PjBL projects, they would rather their children focus on regular assignments that contribute to official final

grades. Teachers also mentioned extra workload as an inhibiting factor, citing examples such as paperwork and marking.

The inhibitions discussed above indicate that replacing old teaching practices with new pedagogy is not always easy. In fact, after the 1-year long pilot project, the school no longer continued with the use of the collaboratively taught inquiry PjBL pedagogy. The reason given for the discontinuation was that the teachers did not have a leader with sufficient expertise (from the university) to guide the teaching team through the pedagogy implementation. Learning from this experience, three years later, the researcher conducted a refined version of the study (see Sect. 3.3.2) in School A and three other schools. This time the study spanned over 2 academic years to give teachers enough time to get accustomed to the new pedagogy. The longer duration has proved to be beneficial in terms of sustainability—the school librarian from School A continued with the pedagogy for several years at least, and involved more subject teachers in the practice. The new practice has been shown to have sunk in; an IT teacher has taken collaborative teaching one step further and has been using Wiki for lesson co-planning with other teachers. Similarly, the librarian from School B (which only participated in the refined study) stated that they were keen to pursue the pedagogy after the study ended. The contrast in sustainability between the pilot study and the refined version reveals that it takes time and continuous effort to introduce practices and make new ones have a long-term impact.

3.3.1.1 Improving Reading Ability with Inquiry Group PjBL

In the same investigation discussed in Sect. 3.3.1 above, the impact of teaching inquiry group PjBL collaboratively on students' reading ability was looked into (Chu et al. 2011b). Researchers were interested in finding out whether inquiry group PjBL could enhance students' intrinsic motivation and interest in reading, thereby encouraging them to read more frequently and more effectively. Its impact on students' reading ability, attitudes, and self-concept was also examined.

Students were required to carry out a group research project on a GS topic in Chinese. Before deciding on their project topic, students had to search for information and read up on potential topics. In the first phase of the project, Chinese Language teachers gave students in-class and take-home exercises that aimed at equipping students with more proficient reading skills. The reading materials came from a wide range of sources including newspaper articles, textbook sections or printed materials from the Internet, all on topics related to the students' group projects. For each in-class exercise, students read an informational text. Their task was to underline key sentences in the article, write a short summary, and provide their own opinions on the topic in 100–150 words. For each take-home assignment, students were told to search for and read a minimum three texts (e.g., articles, books) related to the project theme, and then write a research journal entry of 150–200 words.

A total of 132 students participated in the study, along with 11 teachers and 25 parents. The Progress in International Reading Literacy Study (PIRLS) standard reading test was administered before and after the project phase. The test activated the students' reading comprehension skills and assessed their reading and understanding of informational texts as well as literary text materials. PIRLS also included a component to evaluate students' attitude toward reading (SATR) and their reading self-concept (SRSC). Telephone interviews were also conducted with students, their parents, and teachers to elicit their views on different aspects of inquiry group PjBL. PIRLS scores before and after the inquiry group PjBL were compared using t-tests, with statistical significance set as $p < 0.05$. Questionnaire data were presented as descriptive statistics and box plots, while qualitative interview data were analyzed using the software NVivo 8.

Students' overall informative text and literary text reading performance were recorded to have improved with statistically significant differences following the implementation of inquiry group PjBL. Notably, only students with medium and highly positive attitudes toward reading were found to have made significant improvement in their reading performance in the post-test, whereas those with less favorable attitudes showed no change in their performance. Those who were highly self-efficacious in reading also had significantly better performance in reading overall and in their comprehension of literary texts. Results are listed in Table 3.3. Qualitative findings reflected that students, their parents, and teachers believed that the project enhanced their comprehension skills. A parent was confident that her child now "know the key points" of the reading materials, and a teacher remarked that "students learned how to figure out the main points when reading in Chinese lessons." Parents and teachers further noticed improvements in students' reading speed, vocabulary, and language usage.

Lau and Chan (2003) suggested that learners with good reading abilities possessed better-developed cognitive skills in comprehension to expand their knowledge, and that proficient readers had better metacognitive and analytical thinking skills than poor readers. This study demonstrated that inquiry group PjBL provided adequate opportunities of practice for learners to identify meaningful relationships between elements in texts and to experience an inferential process, whereby they

Table 3.3 Comparison of students' pre-test and post-test reading performance measured by PIRLS (reproduced from Chu et al. 2011b)

Scores	Pre-test		Post-test		t-test
	Mean	SD	Mean	SD	Significant p value
Overall[a]	514.60	120.48	569.64	44.96	0.000*
Literary[b]	537.87	47.35	556.73	48.26	0.000*
Informational[c]	552.99	93.07	562.28	42.69	0.048*

*$p < 0.05$

[a]Overall reading performance, pre-test $N = 151$, post-test $N = 142$

[b]Reading for enjoyment, pre-test $N = 138$, post-test $N = 142$

[c]Reading to acquire and use information, pre-test $N = 138$, post-test $N = 12$

compared and contrasted information repeatedly from different sources (Owens et al. 2002) and this was shown to advance their reading abilities. Learners' increasing ability to identify main points from a passage was an indicator of their enriched reading comprehension skills, which forms an important part of literacy competencies as a twenty-first century skill.

3.3.2 *Case 2: A Refined Collaborative Teaching Approach and Using Social Media in Collaborative Teaching (Chu et al. 2011c; Tavares and Chu 2012)*

Case 2 refined the collaborative teaching approach used in case 1. In a 2-year long project (see Fig. 3.2), students and teachers from four schools were gradually introduced two new pedagogical practices: the inquiry PjBL pedagogy (similar to that of case 1) was introduced to P.4 students (aged 9–10) and teachers in the second semester after researchers had observed the classes learning through traditional methods in the first semester. In the first semester of the second year of intervention, students (now promoted to P.5, aged 10–11) made use of wiki to carry out a GS inquiry group project in Chinese, and also did English co-on paper. In the second semester, they were introduced to the second new pedagogy—English collaborative writing using wiki. Google Sites was used as a teaching and learning platform for the students' completion of their collaborative English writing projects. Each PjBL GS project in the Chinese language lasted over a period of 2–3 months. As for the English writing project, students wrote in groups on paper to experience collaborating with their peers in the first term. In the second term, a wiki platform was introduced for them to perform the task collaboratively using online technology. The project aimed to heighten their information and media literacy through an online collaborative learning environment. Through analyzing the use of wiki in the subjects of GS and the English Language by these primary five students in the four

	Year 1 term 1	Year 1 term 2	Year 2 term 1	Year 2 term 2
Chinese Project	P4 Using traditional method	P4 Using inquiry PjBL	P5 Using inquiry PjBL & Wiki	
English Project			P5 English co-writing on paper	P5 English co-writing with Wiki

Fig. 3.2 An overview of the project in the various stages of the timeframe

primary schools, it was found that the outcomes of inquiry group PjBL are supported by (1) a collaborative teaching approach and (2) the use of social media tools.

Google Sites was used in this study as its interface supports various languages, which fulfills the language requirement of students' projects in both Chinese and English. Google Sites enabled the students to present their project with different sections separated by hyperlinks. Its multimedia features allowed them to present their output in the form of texts, tables, pictures, and/or videos. They could upload different types of materials using the file attachment feature. Moreover, anyone who had access to their wiki platform, their peers and teachers, could leave comments, so they could receive timely feedback on their work. In addition to being able to revise their project at any time, the students could review the earlier versions of their work. Apart from co-constructing the group project, they could use the platform for communication and negotiation purposes through the system's commenting feature. Teachers could also monitor their work output and provide pointers when necessary.

To find out about the influences of wiki on the students' learning experience, an online survey was administered on 420 of them who participated in the GS group project. This cohort had experience with inquiry group PjBL in the previous academic year, using a pedagogical approach similar to that of case 1. The survey questions were adapted from a scale that examined four factors, learning/pedagogy, motivation, group interaction, and technology (Hazari et al. 2009), on a 5-point Likert scale. Forty-two students who took part in the English collaborative writing project attended focus group interviews to share their experience in the use of wiki in group writing and to discuss the advantages and challenges associated with using social media technology. Forty-four teachers from the four participating schools were interviewed on the use of wiki in both GS and English collaborative writing projects. The interview responses were analyzed qualitatively and categorized to form common themes.

All of the measurement scale scores from the questionnaire findings were above the mid point 3.0, indicating that students had positive perceptions on the effects of wiki on all the four aspects of their learning. The results echoed earlier study results that students perceived wiki as a useful instrument for learning (Chu 2008; Chu et al. 2011c; Tavares and Chu 2012). In the domain of learning/pedagogy, their high ratings showed that they recognized wiki as an enabling tool for learning to boost their interests, and supported the use of wiki in other school subjects. In terms of motivation, they felt that the use of wiki reinforced their enthusiasm in group projects. While technological constraints could have dampened their interest in using wiki, they believed that learning to use wiki was worthwhile in terms of time and energy. Equally encouraging was that teachers exclaimed that students, who had not been able to complete their work in the past in the traditional pen-and-paper mode, became more enthusiastic and succeeded in producing higher quality work when wiki was used. The possibility of employing different media to present their GS group projects on wiki (e.g., pictures, video clips) also motivated them toward successful task completion.

As far as group interaction was concerned, students acknowledged wiki as a highly convenient communication tool. Many believed that the collaborative learning process via wiki gave them the environment to reach a consensus, learn from their peers and acquire knowledge and skills in the process of conducting the project. With regard to the technological aspect, they found the interface and wiki features easy to use. They also reported that managing information and materials on wiki was efficient as internet connection enabled them to work simultaneously with collaborators "anytime and anywhere" as well as find and share information easily.

Students who took part in English collaborative writing generally thought that social media technology facilitated peer learning and enhanced their interpersonal skills. Through wiki, they had ample opportunities to evaluate one another's work and reflect on their own, which led to improved quality of their own writing. In an exchange between two students, one of them stressed, "If we use Google Sites as the collaborative platform, we get to read the pieces of writing from other classes, exchange views and comment on our classmates' work. If we write on paper, we can only read a few pieces of work." The other endorsed this view: "Google Sites allows other people to comment on our work and we can learn more from that." In brief, students welcomed having the chance of sharing their work on wiki and appreciated the timely online help and support they offered one another on the wiki platform. Citing a specific instance on wiki, a pupil wrote "Your writing is good but I do not [understand] the meaning of truthful" after reading his classmate's work and the writer response was "truthful means honest." This is solid evidence of mutual exchange and peer learning. Linguistically more able students made more detailed suggestions on their classmates' work by focusing on grammar and vocabulary while their counterparts contributed through other means, for example, by raising stimulating questions which led to revisions. Reading the work of their peers also allowed students to learn from their shared output.

This project had a longer intervention period than its pilot study (case 1), in which two new approaches were introduced step-by-step. This gave teachers more time to familiarize themselves with the new pedagogy, and more opportunities of exploring the new approaches under the guidance of the project team. The time factor was proven critical—schools were more confident in continuing to adopt inquiry PjBL as an approach and social media as a learning tool even without the project team's support after the study, unlike School A's reluctance after the study ended. Teachers perceived wiki to be an effective teaching aid on the whole, despite its use being challenging to some. With the revision history function in wiki, information of what was revised, who made the revision, and when the revision was done could be retrieved (Richardson 2006). This gave it an added advantage. Even the number of revisions in a document could be monitored. As such, teachers were able to monitor the contribution and engagement of learners in the group task, which gave them objective data for assessing student performance (Chu 2008; Woo et al. 2011; Yu et al. 2011).

Findings from this study form the basis of integrating wiki into primary school inquiry group PjBL and classroom teaching. The use of social media technologies, especially wikis, has been shown to have a positive impact on the implementation

of inquiry group PjBL. Both students and teachers reported educational benefits of various kinds, and the current findings lend further support to the potential benefits of introducing wiki in collaborative teaching practices.

3.3.3 *Case 3: Collaborative Learning in Mainland China (Li et al. 2012)*

In addition to Hong Kong-based projects, a study was done by Li et al. (2012) in Shenzhen, China to explore the outcomes of collaborative writing in Chinese among 59 upper primary Chinese students with an average age of 10 years old, using a Wiki-based Collaborative Process Writing Pedagogy (WCPWP). In this study, the researchers investigated the effects of learning with WCPWP, the level of performance, and the attitudes of the students toward WCPWP. A total of fifty-nine grade 4 students from a Shenzhen primary school participated in the study. The researchers and the Chinese language teacher collaborated to set up a wiki platform using MediaWiki and co-planned lessons. The students were divided by teachers into groups of four, two of whom possessed a higher Chinese writing ability than their other team-mates. They worked as a group to compose one wiki page and produce a piece of composition as a final product. The teacher guided and facilitated communication within and between different groups throughout the project implementation.

Students in each group wrote one joint composition on a single wiki page. The use of a wiki required social interaction among students and between students and teachers, leading to the cocreation of knowledge as a result of social interaction, as articulated by the social constructivist theory (Vygotsky 1987). Students in different groups could view and comment on each other' writing, and the teacher could choose to be involved to provide each group with guidance and help facilitate their writing. Throughout the process, students read and responded to texts in the written form. The writing process is believed to describe what students think and do as they write (Tompkins 2008), which is central to the social view of the process writing theory (Faigley 1986). For easy identification of each stage in the writing process, the collaborative writing task was conceptualized as a nonlinear and recurrent cyclic series of four stages: group prewriting, group drafting, revising, and editing. The progress of the four stages was monitored by all group members.

Using MediaWiki, students and teachers could work together on writing projects that demanded a high level of interaction. Patterns of collaboration in the writing process were captured in the observational data. The data indicated that students negotiated with their peers for at least 4 min in the prewriting stage by discussing the writing content and division of labor within the group though, at times, divergent viewpoints slowed down their progress. Cooperation was evidenced by students agreeing to allocate different paragraphs to different group members. As the wiki platform does not allow students to write simultaneously on the same page,

they took turns to compose their group wiki page. In other words, while a group member was working on the wiki page, other members wrote in Microsoft Word, and they updated the wiki page at 10-min intervals one after another. After submitting their individual contributions, together they revised and edited the piece to completion.

The two compositions were juxtaposed for a comparison of the difference in participation behavior and scores. Composition Two had a sum of 113 modifications, which was much higher than the total number of 58 in Composition One. 10 of the 14 participating groups were found to achieve higher scores in Composition Two. The mean score improved by 3.79 marks (26 % improvement) when compared to Composition One, statistically significant at $p < 0.05$ by paired-sampled t-test. The Motivation, Group interaction, and Audience subscale scores were higher than 3 (Neutral = 3) on average, suggesting that WCPWP was positively received by students. As for learning benefits, the students perceived WCPWP to be beneficial in boosting their writing motivation, improving their writing ability, computer skills, and collaboration skills. They conceived WCPWP to be conducive to increased group interaction, which enriched their knowledge and enhanced their writing ability. For advantages in the technical domain, they appreciated being able to write in and after class, acknowledging that MediaWiki made it easier for peer editing, revision, and commenting.

3.3.4 Case 4: Developing IL Skills in a Secondary School Using Inquiry Group PjBL

IL is one of the core capabilities alongside media and technology literacy in digital literacy skills to be cultivated. IL is considered to be necessary for students to be able to access and evaluate information efficiently and critically, and then use and manage a wide variety of information in an accurate and ethical manner, in order to advance academically and in their career in the twenty-first century (P21 2009). This section discusses the effectiveness of implementing collaborative inquiry group PjBL with wiki in developing the IL skills of junior secondary students. Over a period of three years, the researchers studied the impact of using inquiry group PjBL in Liberal Studies in strengthening the students' IL skills adapted from the "Tools for Real-time Assessment of Information Literacy Skills" (TRAILS) measure (TRAILS 2004), and examined which aspects of IL the students performed well and poorly (Chu et al. 2012a, b, c). With the initial results, the researchers focused on students' tendency of plagiarizism, and explored how wiki group projects could be used to guide students to use information responsibly and ethically (Yeung et al. 2012; Siu et al. 2014).

One hundred and seventy six secondary 1 (aged 12–13) and 185 secondary 2 (aged 13–14) academically high-achieving students from 10 classes in a public school in Hong Kong participated in this Liberal Studies inquiry group PjBL

project using the wiki platform. The students collaborated as project teams in groups of 5–6. The teacher–researchers taught the students how to construct their own wiki site on Google Sites. Each group then wrote a project report using the collaborative writing platform, including information about the background of the study, the literature review, design and methodology, findings, data analysis and discussion, conclusion, as well as limitations and suggestions. To assess students' learning outcomes in IL, the projects were first analyzed by a free online plagiarism checker and Small SEO Tools (SmallSEOTools.com 2010), followed by a further manual examination by the researchers.

The study aimed at teasing out which of the five aspects of IL were the most challenging to the students. The TRAILS (2004) test was administered to measure IL skills in five domains: Category A—Develop Topic; Category B—Identify Potential Sources; Category C—Develop, Use and Revise Search Strategies; Category D—Evaluate Sources and Information, and Category E—Recognize How to Use Information Responsibly, Ethically, and Legally. The online version of TRAILS Grade Six level with 15 multiple choice questions was used to measure the students' strengths and weaknesses in IL. The benchmark score for TRAILS was 65 % according to the U.S. standards. Both secondary 1 and 2 students performed well in identifying potential sources (Overall average: secondary 1 = 75.3 %, secondary 2 = 73.3 %), but poorly in using information responsibly and ethically (Overall average: secondary 1 = 40.5 %, secondary 2 = 29.5 %). Among the 5 categories, they performed best in Category B, moderately in D, C, and A, and poorly in Category E.

Students' time spent on the Wiki platform was believed to have a positive relationship with their project performance. An assistant principal of the participating school reported that students who actively used PBworks for their PjBL learning won the first, second, and fourth grand prizes in a Liberal Studies project open competition, and was confident that their success could be largely attributed to PBworks (Chin, personal communication, May 2015). The study thus demonstrated that inquiry group PjBL with wiki worked well in secondary school to develop students' IL skills. However, much more had to be done for the improvement to be seen in students' ethical use of information.

In light of the above findings, Yeung et al. (2012) were eager to find a solution to reduce plagiarism offenses in the 15 inquiry group project teams among the secondary 1 student (aged 12–13) of the same school. In the first year, the researchers and teachers deepened the students' understanding of what plagiarism is and what it is not, and ways to avoid it. Preliminary assessment revealed that 87 % of the students plagiarized as shown in their work on wiki. In subsequent years, the researchers worked more closely with the teachers in developing strategies that promoted plagiarism-free inquiry learning. These included modifying the assignment specifications to state that the IL homework, use of proper citations and level of plagiarism counted toward the final grades. Moreover, the students were given specific comments in the completed IL assignments regarding their ability to use

information sources and proper citations. After the students' written work was submitted for plagiarism check, the researchers provided individual reports for the teachers to brief the students. Students also received instructions on how to use an online citation tool called "Citation Machine," which allowed them to cite properly and easily (Siu et al. 2014).

In order to check whether students improved in the ethical use of sources, before and after the intervention, students' collaborative writings on wiki were submitted to an online free plagiarism checking tool called "Small SEO Tools" that supports both English and Chinese texts. Material submitted is automatically compared to information available on the Google platform (SmallSeoTools.com 2010). The tool generates an index that indicates the "uniqueness" or originality of the submitted content, showing the extent to which the texts were written using the students' own words. In addition, their work was rated by a plagiarism assessment scale consisting of four levels to signify the seriousness of plagiarism, from Level 1 "No plagiarism has been found" to Level 4 "Copy a block of text of over 40 words without citation." They were also asked two questions concerning their IL skills in plagiarism, which assessed their ability to identify plagiarism behavior, and evaluated their knowledge of constructing proper citations (Yeung et al. 2012).

Out of the 15 project teams, only two did not commit any form of plagiarism. One team was found to have plagiarized on a minor level. Nine teams committed plagiarism classified at the moderate level, owing to insufficient knowledge in the ways and formats of citation. Students explained that this was their very first training in citing sources, as such content was included neither in the primary school curriculum nor in that in secondary school previously. Three groups showed serious levels of plagiarism, believing that information on the Internet could be used freely without acknowledgement, further showing the lack of education in the ethical use of information. However, the pre- and post-test on IL knowledge suggested that the students significantly increased their knowledge on the topic, but needed more time to assimilate the information and put their knowledge into practice.

In a subsequent study (Chu 2014; Lee et al. 2016), the instructional design was refined and named the UPCC pedagogy featuring 4 stages: **U**nderstanding plagiarism, learning about **P**araphrasing and related skills, generating proper **C**itations with an online citation tool, and doing originality **C**heck with an online tool in helping students avoid plagiarism. Following the four steps, the project team yielded better results in enabling younger students (secondary 1–3; aged 11–13) to avoid plagiarism behavior and use information ethically and legally. Descriptive statistics revealed a trend toward improvement in students' plagiarism over 2 years, with the percentage of groups that showed no plagiarism behavior increased from 73.4 to 84 %, and groups found with minor and moderate plagiarism decreased from 17.2 to 8 % to 1.6 to 0 %, respectively (Chu and Hu 2016). The findings reinforced the message that education on IL, in particular the ethical use of information, required continuous effort, and attention in order for students' awareness of plagiarism to be heightened.

3.4 Conclusion

In this chapter we presented four in-depth cases studies on the use of inquiry group PjBL and its impact on facilitating the development of twenty-first century skills among primary and secondary level students, both in Hong Kong and in Mainland China. Our review on the existing literature about approaches and tools used in collaborative teaching and learning shows that such applications have been widely adopted around the world with positive results. Our case studies demonstrate that a combination of collaborative teaching and social media platforms is effective in developing students' twenty-first century skills across subjects, different age ranges, and locations. Case 1 reflected how students developed IL, capacity for self-directed learning as well as reading ability using wiki. Case 2 illustrated that students could develop digital literacies with the use of Wiki technology in inquiry group PjBL projects. Case 3 proved that using Wiki technology motivated students to participate in projects and improved their digital literacies and writing skills, and boosted their learning motivation. Case 4 stressed the importance of giving students appropriate support in IL, especially on the ethical use of sources and information, while completing their inquiry group PjBL project. Through these case studies, we have seen that inquiry group PjBL plays a vital role in the learning process to comprehensively improve students' twenty-first century skills.

The findings of the case studies lend support to the use of inquiry group PjBL as a promising teaching and learning approach, not only for core subjects but also for learning and innovation, digital literacy, and life and career skills for twenty-first century learners. Constructivist teaching approaches create opportunities for learners to extend their own knowledge by engaging them in stimulating learning experiences. They are able to, and more importantly, motivate to actively develop their own understanding by expanding their existing knowledge through active reasoning. In line with constructivist principles, inquiry group PjBL could be an effective strategy employed to equip learners with twenty-first century skills. Such an approach is expected to be more effective when social media technologies are utilized and when teachers are sufficiently prepared to take part in collaborative teaching and guide their students in collaborative learning.

References

American Library Association. (1989). *Presidential committee on information literacy: Final report*. Chicago, IL: ALA.

American Association of School Librarians (AASL). (2007). *Standards for the 21st—Century Learner.* Retrieved May 11, 2015 from http://www.ala.org/aasl/standards

Avci, U., & Askar, P. (2012). The comparison of the opinions of the university students on the usage of blog and wiki for their courses. *Journal of Educational Technology & Society, 15*(2), 194–205.

Bautista, A., Tan, L. S., Ponnusamy, L. D., & Yau, X. (2015). Curriculum integration in arts education: connecting multiple art forms through the idea of 'space'. *Journal of Curriculum Studies*, 1–20.

Carless, D. (2006). Collaborative EFL teaching in primary schools. *ELT Journal, 60*(4), 328–335.

Carless, D., & Walker, E. (2006). Effective team teaching between local and native-speaking English teachers. *Language and Education, 20*(6), 463–477.

Casey, G. (2013). Social media in the classroom: A simple yet complex hybrid environment for students. *Journal of Educational Multimedia and Hypermedia, 22*(1), 5–24.

Cheese, P. (2008). *Netting the net generation. Businessweek.com.* Retrieved May 11, 2015 from http://www.bloomberg.com/bw/stories/2008-03-13/netting-the-net-generationbusinessweek-business-news-stock-market-and-financial-advice

Chen, H. M., Yu, C., & Chang, C. S. (2007). E-Homebook system: A web-based interactive education interface. *Computers & Education, 49*(2), 160–175.

Chen, P. (2008). Strategic leadership and school reform in Taiwan. *School Effectiveness and School Improvement, 19*(3), 293–318.

Chu, S. (2014). *Developing 21st century skills with plagiarism-free inquiry learning, collaborative teaching, social media, and gamification*. Paper presented at the Learning and Teaching Expo 2014, Hong Kong.

Chu, S. K. W. (2008). TWiki for knowledge building and management. *Online Information Review, 32*(6), 745–758.

Chu, S. K. W. (2009). Inquiry project-based learning with a partnership of three types of teachers and the school librarian. *Journal of the American Society for Information Science and Technology, 60*(8), 1671–1686.

Chu, S. K. W. (2016). *Examining the effectiveness of plagiarism-free inquiry learning in the junior secondary school setting*. Paper presented at Social Media 2016, Hong Kong.

Chu, S. K. W., Chan, C. K., & Tiwari, A. F. (2012b). Using blogs to support learning during internship. *Computers & Education, 58*(3), 989–1000.

Chu, S. K. W., & Hu, X. (2016, April). *Surveys on plagiarism in assignments of students in secondary schools and introduction of UPCC model in avoiding plagiarism*. Paper presented at Social Media 2016, The 25th International Education and Technology Conference, Hong Kong

Chu, S. K. W., & Kennedy, D. M. (2011). Using online collaborative tools for groups to co-construct knowledge. *Online Information Review, 35*(4), 581–597.

Chu, S. K. W., Tang, Q., Chow, K., & Tse, S. K. (2007). *A study on inquiry-based learning in a primary school through librarian-teacher partnerships*. Paper presented at the 36th Annual Conference of the International Association of School Librarianship, and the Eleventh International Forum on Research in School Librarianship. Taipei, Taiwan: International Association of School Librarianship.

Chu, S. K. W., Tavares, N. J., Chu, D., Ho, S. Y., Chow, K., & Siu, F. L. C. (2012c). *Developing upper primary students' 21st century skills: inquiry learning through collaborative teaching and Web 2.0 technology*. Hong Kong: Centre for Information Technology in Education, Faculty of Education, The University of Hong Kong.

Chu, S. K. W., Tse, S., & Chow, K. (2011a). Using collaborative teaching and inquiry project-based learning to help primary school students develop information literacy and information skills. *Library & Information Science Research, 33*(2), 132–143.

Chu, S. K. W., Tse, S. K., Loh, E. K. Y., & Chow, K. (2011b). Collaborative inquiry project-based learning: Effects on reading ability and interests. *Library & Information Science Research, 33*(3), 236–243.

Chu, S. K. W., Wong, K., Lee, C., Chow, K. & Ng, J. (2011c). *Inquiry project-based learning with wiki at primary five level.* Paper presented at CITE Research Symposium 2011. Hong Kong: The University of Hong Kong.

Chu, C. B. L., Yeung, A. H. W., & Chu, S. K. W. (2012a). *Assessment of students' information literacy: A case study of a secondary school in Hong Kong*. Paper presented at CITE Research Symposium 2012. Hong Kong: The University of Hong Kong.

David, J. (2008). What research says about project-based learning. *Educational Leadership, 65*, 80–82.

Du, H. S., Chu, S. K. W., Chan, R. R. C. & He, W. (in press). Collaborative writing with Wikis: An empirical investigation. *Online Information Review*.

Edelson, D. C., Gordin, D. N., & Pea, R. D. (1999). Addressing the challenges of inquiry-based learning through technology and curriculum design. *Journal of the Learning Sciences, 8*(3–4), 391–450.

Faigley, L. (1986). Competing theories of process: A critique and a proposal. *College English*, *48* (6), 527–542. http://www.jstor.org/pss/376707

Fung, K. Y., Chu, S. K. W., Tavares, N., Ho, G., & Kwan, K. (2011). *Using Google Sites in English collaborative writing*. Paper presented at CITE Research Symposium 2011. Hong Kong: The University of Hong Kong.

Gallagher, S. A., & Gallagher, J. J. (2013). Using problem-based learning to explore unseen academic potential. *Interdisciplinary Journal of Problem-based Learning, 7*(1), 111–131.

Goddard, Y. L., Goddard, G. D., & Tschannen-Moran, M. (2007). A theoretical and empirical investigation of teacher collaboration for school improvement and student achievement in public elementary schools. *Teachers College Record, 109*(4), 877–896.

Harada, V. H., & Yoshina, J. M. (2004a). *Inquiry learning through librarian-teacher partnerships*. Worthington, OH: Linworth Publishing.

Harada, V. H., & Yoshina, J. M. (2004b). Moving from rote to inquiry: Creating learning that counts. *Library Media Connection, 23*, 22–24.

Harada, V., Kirio, C., & Yamamoto, S. (2008). *Collaborating for project-based learning in grades 9-12*. Worthington, OH: Linworth Publishing Inc.

Harada, V. H., & Yoshina, J. M. (2010). *Assessing for learning: Librarians and teachers as partners. Revised and expanded* (2nd ed.). Westport, CT: Libraries Unlimited.

Hazari, S., North, A., & Moreland, D. (2009). Investigating pedagogical value of wiki technology. *Journal of Information Systems Education, 20*(2), 187–198.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist, 42*(2), 99–107.

Islam, M. N. (2011). Collaboration between native and non-native English-speaking teachers. *Studies in Literature & Language, 2*(1), 33–41.

Johnston, M. P. (2012). Connecting teacher librarians for technology integration leadership. *School Libraries Worldwide, 18*(1), 18–33.

Konzal, J. L. (2001). Collaborative inquiry: A means of creating a learning community. *Early Childhood Research Quarterly, 16*(1), 95–115.

Krajcik, J., Blumenfeld, P. C., Marx, R. W., Bass, K. M., Fredricks, J., & Soloway, E. (1998). *Journal of the Learning Sciences*, *7*, 313–350.

Kuhlthau, C., Maniotes, L., & Caspari, A. (2007). *Guided inquiry: Learning in the twenty-first century*. Westport, CT: Libraries Unlimited.

Kuhlthau, C., Maniotes, L., & Caspari, A. (2015). *Guided inquiry: Learning in the twenty-first century* (2nd ed.). Westport, CT: Libraries Unlimited.

Lau, K. L., & Chan, D. W. (2003). Reading strategy use and motivation among Chinese good and poor readers in Hong Kong. *Journal of Research in Reading, 26*, 177–190.

Leadbeater, C. (2009). *WE-THINK: Mass innovation, not mass production*. London: Profile Book Ltd.

Lee, C. W. Y., Chu, S. K. W. & Yue, J. O. (2016). *Plagiarism-free inquiry project-based learning with UPCC pedagogy*. Paper accepted for the ASIS&T 2016 Annual Meeting, Copenhagen, Denmark.

Lee, J. S., & Bowen, N. K. (2006). Parent involvement, cultural capital, and the achievement gap among elementary school children. *American Educational Research Journal, 43*(2), 193–218.

Lee, L. (2010). Exploring wiki-mediated collaborative writing: A case study in an elementary Spanish course. *Calico Journal, 27*(2), 260–272.

Li, X., Chu, K., Ki, W. W., & Woo, M. (2012). Using a wiki-based collaborative process writing pedagogy to facilitate collaborative writing among Chinese primary school students. *Australasian Journal of Educational Technology, 28*(1), 159–181.

Liang, M., Chu, S., Siu, F., & Zhou, A. (2009). *Comparing user experiences in using Twiki & Mediawiki to facilitate collaborative learning*. Paper presented at the International Conference on Knowledge Management [CD-ROM]. Hong Kong.

Liou, Y. H. H. (2011). Using Google sites to communicate with parents: A case study. *Language Testing in Asia, 1*(2), 68.

Lomos, C., Hofman, R. H., & Bosker, R. J. (2011). The relationship between departments as professional learning communities and student achievement in secondary schools. *Teaching and Teacher Education, 27*(4), 722–731.

Luo, W. H. (2007). A study of native English-speaking teacher programs in elementary schools in Taiwan. *Asia Pacific Education Review, 8*(2), 311–320.

Luo, W. H. (2014). An inquiry into the NEST program in relation to English teaching and learning in Taiwanese primary schools. *English Language Teaching, 7*(1), 149–158.

Mackey, T. P., & Jacobson, T. E. (2005). Information literacy: A collaborative endeavor. *College Teaching, 53*(4), 140–144.

Mak, B., & Coniam, D. (2008). Using wikis to enhance and develop writing skills among secondary school students in Hong Kong. *System, 36*(3), 437–455.

Mokhtar, I. A., & Majid, S. (2006). An exploratory study of the collaborative relationship between teachers and librarians in Singapore primary and secondary schools. *Library & Information Science Research, 28*(2), 265–280.

Montiel-Overall, P. (2008). Teacher and librarian collaboration: A qualitative study. *Library & Information Science Research, 30*(2), 145–155.

Owens, R. F., Hester, J. L., & Teale, W. H. (2002). Where do you want to go today? Inquiry-based learning and technology integration. *Reading Teacher, 55*, 616–625.

Pardy, D. (2004). The perceived effectiveness of simultaneous team-teaching in a dual language programme. *Journal of Research in International Education, 3*(2), 207–224.

Partnership for 21st Century Skills [P21]. (2009). *P21 framework definitions*. Retrieved May 11, 2015 from http://p21.org/storage/documents/P21_Framework_Definitions.pdf

Pawan, F., & Ortloff, J. H. (2011). Sustaining collaboration: English-as-a-second-language, and content-area teachers. *Teaching and Teacher Education, 27*(2), 463–471.

Richardson, W. (2006). *Blogs, wikis, podcasts and other powerful web tools for classrooms*. Thousand Park, CA: Corwin Press.

Rimor, R., Rosen, Y., & Naser, K. (2010). Complexity of social interactions in collaborative learning: The case of online database environment. *Interdisciplinary Journal of E-Learning & Learning Objects, 6*, 356–365.

Seginer, R., & Vermulst, A. (2002). Family environment, educational aspirations, and academic achievement in two cultural settings. *Journal of Cross-Cultural Psychology, 33*(6), 540–558.

Shen, C. Y., & Wu, C. H. (2011). An exploration of students' participation, learning process, and learning outcomes in Web 2.0 computer supported collaborative learning. *International Journal of Online Pedagogy and Course Design* (IJOPCD), *1*(2), 60–72.

Siu, F. L. C., Chan, R. C. H., Law, O. K. L., & Chu, S. K. W. (2014). *Plagiarism-free inquiry learning*. Paper presented at the CITE Research Symposium 2014. Hong Kong: The University of Hong Kong.

SmallSEOTools.com. (2010). *What is the plagiarism checker?* Retrieved May 11, 2015 from http://www.smallseotools.com/plagiarism-checker/

Sung, C. C. M. (2014). An exploratory study of Hong Kong students' perceptions of native and non-native English-speaking teachers in ELT. *Asian Englishes, 16*(1), 32–46.

Tavares, N., & Chu, S. (2012). *Experimenting with English collaborative writing on Google sites*. Proceedings of the 4th International Conference on Computer Supported Education, Vol. 1, pp. 217–222.

Thomas, P., King, D., & Minocha, S. (2009). The effective use of a simple wiki to support collaborative learning activities. *Computer Science Education, 19*(4), 293–313.

Tompkins, G. E. (2008). *Literacy for the 21st Century: A balanced approach* (5th Edition). Boston: Allyn & Bacon.

TRAILS. (2004). *Tool for real-time assessment of information literacy skills.* Retrieved May 11, 2015 from http://www.trails-9.org/

Vangrieken, K., Dochy, F., Raes, E., & Kyndt, E. (2015). Teacher collaboration: A systematic review. *Educational Research Review, 15*, 17–40.

Vygotsky, L. S. (1987). Development of higher mental functions during the transition age. In R. W. Rieber (Ed.), *The collected works of L.S. Vygotsky* (pp. 83–150). New York: Plenum Press.

Wong, L. H., Chen, W., Chai, C. S., Chin, C. K., & Gao, P. (2011). A blended collaborative writing approach for Chinese L2 primary school students. *Australasian Journal of Educational Technology, 27*(7), 1208–1226.

Woo, M., Chu, S., Ho, A., & Li, X. (2011). Using a wiki to scaffold primary-school students' collaborative writing. *Journal of Educational Technology & Society, 14*(1), 43–54.

Yeung, A. H. W., Chu, C. B. L., & Chu, S. K. W. (2012). *Explore the behavior of plagiarism at the secondary school level in Hong Kong*. Paper presented at CITE Research Symposium 2012. Hong Kong: The University of Hong Kong.

Yeung, A. H. W., Chu, C. B. L., Chu, S. K. W., & Fung, C. (in press). Exploring junior secondary students' plagiarism behavior. *Journal of Librarianship & Information Science*.

Yu, C. T., Fong, C. S., Kwok, W. K., Law, S. M., Chu, S. K. W., & Ip, I. (2011). *Using Google sites in collaborative inquiry projects in General Studies.* Paper presented at CITE Research Symposium 2011. Hong Kong: The University of Hong Kong.

Zmuda, A., & Harada, V. H. (2008). Librarians as learning specialists: Moving from the margins to the mainstream of school leadership. *Teacher Librarian, 36*(1), 15–20.

Chapter 4
Twenty-First Century Skills Education in Switzerland: An Example of Project-Based Learning Using Wiki in Science Education

Chapter 3 has introduced teaching pedagogies and learning strategies that promote and sustain the development of twenty-first century skills among students in the fields of the social sciences, humanities, and languages. It has also illustrated approaches used in collaborative teaching, inquiry-based learning (IBL), project-based learning (PjBL) as well as the use of social media tools such as wiki that are potentially conducive to student learning (e.g., Chu 2008; Notari 2006; Tavares et al. 2011; Woo et al. 2011). These methods and tools not only encourage exchange of ideas, comments, and constructive feedback (Mak and Coniam 2008) but also foster collaboration (Notari 2006), improve work quality (Chu 2008) and cultivate social skills in the course of negotiation (Fung et al. 2011; Notari et al. 2014). When learners are challenged to rethink and restructure their ideas, it helps to develop their skills and cognitive abilities that go beyond those of the actual subject matter.

Compared to instruction in the social sciences, humanities, and languages, a slightly different approach is required to promote twenty-first century skills in science education. The goal of science education is to develop students' scientific literacy, involving the understanding of scientific norms and concepts, and the ability to reproduce scientific content and express the related matters autonomously and adequately (Miller 1983). In order to achieve this goal, approaches in addition to those outlined in Chap. 3 are needed. As such, this chapter first presents an overview of the various approaches that could be used to scaffold learners' development of scientific literacy, followed by an introduction to the methodological approach ABAHCOCOSUCOL (Notari 2006) which was initiated in Switzerland to improve science instruction in high schools. Guided by the progressive inquiry-based model proposed by Hakkarainen and Sintonen (2002) and Muukkonen et al. (2008), ABAHCOCOSUCOL makes use of a technology-supported environment to create room for interactivity and participation. Students produce a wiki out of questions and explanations embedded in a hyperlink structure, in which they review, restructure, rewrite, and reorganize their collaboratively produced contents. This structure of production, comparison, and regrouping results

S.K.W. Chu et al., *21st Century Skills Development Through Inquiry-Based Learning*, DOI 10.1007/978-981-10-2481-8_4

in a sharing of expertise among learners and promotes knowledge acquisition, transfer, and consolidation. The combination of the most relevant aspects that support scientific literacy and their embedment into an interactive learning environment facilitates the development of critical thinking skills, active participation, cognitive abilities, and twenty-first century skills.

4.1 Notable Aspects of Science Education

Many approaches and models have emerged to describe and analyze science education and proposed important aspects that might be helpful for its advancement. Their goal is to conceptualize instructional design and the development of skills and competences that improve learners' achievement.

4.1.1 Models of Science Education

The competence model HarmoS ("Harmonisierung der obligatorischen Schule") appeared in the course of an educational policy reform in Switzerland to describe the development of skills and competences that learners are expected to demonstrate in science subjects (Labudde and Adamina 2008; Ramseier et al. 2011). This model was designed by a consortium for science education in Switzerland to determine the goals of science education and to create a corresponding competence model to validate, revise, and suggest basic standards illustrated by concrete examples (Ramseier et al. 2011) (Fig. 4.1).

The model is constructed as a three dimensional matrix that spans the instructional framework of science education. The first dimension, representing skills, lies on the horizontal axis. The second dimension positioned on the intersecting vertical axis captures the domains of the concerned subject, and the third dimension on the vertical axis shows the varying levels of difficulty (Ramseier et al. 2011).

The consortium for science education in Switzerland places the behavioral aspects on the primary axis, with the vertical axis orienting around the primary axis. Every behavioral aspect can be measured by four difficulty levels defined on the vertical axis to be reached at the end of grade 2, 6, and 9, respectively. The difficulty heightens from "simple exploration by doing" to "exploration by asking and doing" and from "research oriented explorations" to "organization and realization of research oriented explorations" (Labudde and Adamina 2008). Consequently, the matrix signifies a broad and complex framework of level descriptions which was designed according to progression logic. A horizontal progression would imply that an increasing number of aspects are to be included; the additional dimension that holds the teaching content on the horizontal axis is further divided into eight sub-aspects that represent specific subcategories of the teaching content. On the vertical axis, progression along the axis reveals a higher

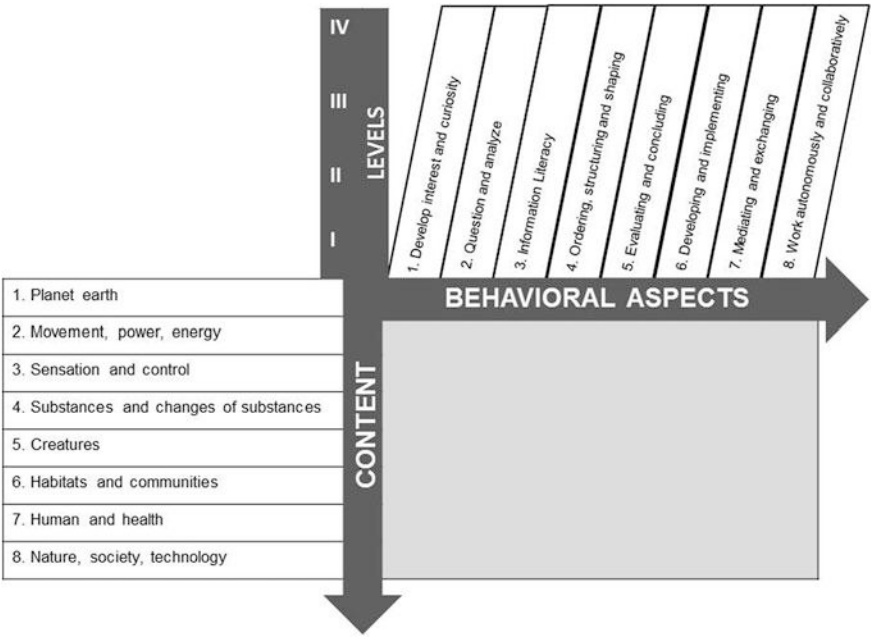

Fig. 4.1 The HarmoS competence model (adapted from Labudde and Adamina 2008, p. 354)

differentiation among the partial aspects and an increased requirement of competences (Ramseier et al. 2011).

The effort of the consortium to shape and define competences for science education is a trend in many different countries all over the world. This raises the question as to whether these models have to be designed country-specifically or if they actually share certain underlying competences (Labudde and Adamina 2008). According to Labudde and Adamina (2008), the models all originate from the concept of scientific literacy, a term that has been prevalent in the discourse of science didactics for many years. However, scientific literacy is a term that is "often used, but seldom defined" (Miller 1983, p. 29). Generally, it can be regarded as a combination of understanding scientific norms and knowledge of major constructs in addition to the ability to reproduce scientific content and express the related matters autonomously and adequately (Miller 1983). Based on the Programme for International Student Assessment (PISA), a scientific literate person is expected to possess the following knowledge and abilities (Hammann 2006):

- Understand basic scientific concepts
- Understand science and the application of scientific knowledge
- Possess scientific knowledge and be able to distinguish it from nonscientific knowledge
- Have the ability and motivation for autonomous life-long learning
- Have the ability to use scientific knowledge to solve problems

- Possess knowledge to participate in scientifically motivated social discussions
- Understand the Nature of Science (NOS)
- Meet science with appreciation, curiosity, and astonishment
- Possess knowledge about usage and risk of science
- Critically reflect on science and be able to handle scientific expertise.

The points listed above suggest that it is crucial for students to understand and apply scientific concepts. Therefore, concept learning is a salient aspect of the instructional design of science education (Labudde et al. 1988). "If students have a fragmented knowledge base, inadequate retrieval processes and the inability of distinguishing between concepts and reasoning modes used in science as opposed to those used in everyday life" (Labudde et al. 1988, p. 81), they can only attain a superficial understanding of scientific concepts. These problems often arise because of the form of mediation of a new scientific concept, especially in the area of Physics and Mathematics, where teachers tend to explain a new concept by introducing the verbal or mathematical definitions that describe the significant features of a concept. However, little is conveyed about the actual process that governs identification or construction of a concept and students have to deduce this procedural knowledge on their own, which is often complicated by insufficient interpretative abilities. To go further, the mediation of concepts often lacks explicit references to existing conceptions. Scientific concepts ought to be set in a comparative context to enhance cognitive linking between new and preexisting knowledge and establish integration and accommodation, both required for effective learning (Labudde et al. 1988; Piaget 1970). These difficulties lend themselves to the suggestion of instructional principles for more effective teaching of scientific concepts. Procedural knowledge for interpreting scientific knowledge has to be taught in combination with the corresponding definition and description of a concept. New knowledge has to be mediated coherently to guarantee memorability and contextualization within the conceptual framework that already exists with a focus on facilitating the integration of new content into preexisting frameworks. This approach of embedding and contrasting acquired knowledge within and with the prior conceptual framework supports the elimination of inconsistencies and establishes a coherent knowledge base (Labudde et al. 1988).

A method that presents a promising solution in this respect can be found in constructivist learning (Widodo and Duit 2004), generally defined as the act of active construction of new knowledge or skills out of preexisting capabilities of teachers and students (Labudde 2008). A constructivist learning environment can be beneficial in many different ways. A study on the general characteristics of such methods reveals that a learning environment that enhances curiosity and inquiry, creative and revolutionary thinking, collaborative and autonomous learning and integration of scientific concepts is the key to constructivist learning (Widodo and Duit 2004). In line with this, Labudde (2003) points out that a constructivist learning approach would most often lead to interdisciplinary science instruction, an approach that supports students' understanding of scientific concepts, as they are mediated in a broader context. Interdisciplinary teaching takes the advantage of the

interrelation of the scientific subjects like Biology, Chemistry, or Physics. By combining these scientific subjects, the science curriculum can be more comprehensive. A model was developed by Labudde et al. (2005) to ensure effective and successful interdisciplinary teaching in science education while describing and defining its multidimensional complexity (Fig. 4.2).

Derived from the current body of research on interdisciplinary teaching and targeted surveys, the model contains seven dimensions that cover several parts of the approach. Every dimension is further divided into three to four facets, each representing one branch of a mind-map that spans the whole multidimensional space of the model. The facets themselves consist of several components that are distributed over a defined range close to the branch itself, either closely related to a specific subject or rather interdisciplinary aligned. Special attention should be directed to the dimension "Transferable Skills" that resembles the twenty-first century skills outlined. Labudde et al. (2005) emphasize the significance of aspects like "Information Literacy," "Ability to cooperate," "Ability to differentiate and integrate," "Tolerance of Ambiguity," or "Problem-solving skills" and the shift the focus to skills and competencies beyond the actual subject matter.

In relation to this approach, a theoretical framework (Fig. 4.3) is developed to safeguard the quality of instruction in Physics education (Fischer et al. 2014). The model concentrates on four dimensions: Teacher, Instruction, Student, and Outcomes, and contains a number of variables that have been found to have a positive impact on students' achievement in science instruction based on previous research.

In the above model, teacher-related factors, including teachers' professional knowledge, enthusiasm, and their background in terms of teaching experience, and

Fig. 4.2 The multidimensional model of interdisciplinary teaching (adapted from Labudde et al. 2005, p. 105)

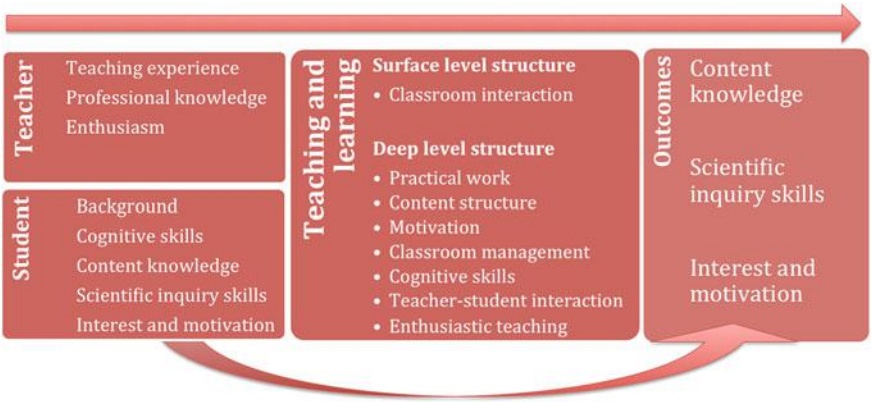

Fig. 4.3 Model of quality instruction in physics (adapted from Fischer et al. 2014)

student-related factors, such as their cognitive ability, prior knowledge, inquiry skills, interest, and motivation and general background, are factors that positively influence the quality of instruction (Fischer et al. 2014). The dimension "instruction" is divided into two levels—surface and deep. The surface level contains directly observable characteristics like the form of classroom interaction. The deep level focuses on cognitive activation, structure of the content, management of the classroom, motivational support and learning orientation, practical work, as well as teacher–student interactions and the teacher's behavior. The "Outcomes" are primarily concerned with the concept of scientific literacy with respect to the students' content knowledge and their skills in the area of scientific experiments. In addition, Fischer et al. (2014) introduced the aspects of motivation and interest as an instructional outcome. As Fig. 4.3 suggests, teacher-related variables affect instruction and therefore implicitly impact on the instructional outcomes, whereas student-related factors have a direct effect on this variable. Even though the model was originally constructed to investigate instructional differences in Physics instruction among Germany, Switzerland, and Finland teachers, the instructional factors illustrated in the model are highly relevant to the learning success of students and the constructional principles can be applied to enhance science education and support scientific literacy in different contexts.

With regard to the intentions of creating this proposed model, IBL and PjBL offer a promising solution to meet the qualitative requirements of scientific instruction. Referring to the "Instruction" dimension of the model, inquiry-based learning presents students as active agents in a constructivist information search process that covers Initiation, Selection, Exploration, Formulation, Collection, Presentation, and Assessment (Kuhlthau 2004; Kuhlthau et al. 2007). Kuhlthau (2010) recommends that in a constructivist guided inquiry-type learning environment, the instructional team holds an observational perspective to teach and assess learners and be sensitive to learning needs that emerge. In contrast, a progressive inquiry model (Hakkarainen and Sintonen 2002; Muukkonen et al. 2008) sees the

teacher as the creator of a context for inquiry by introducing a multidisciplinary approach to a theoretical or real-life phenomenon, after which the learners start formulating their own questions. The questions and explanations are shared and evaluated together, which involves utilization of authoritative information sources and iterative elaboration of subordinate study questions and more advanced theories, explanations and writings. The progressive inquiry model is not meant to be adhered to in a rigid manner; rather it offers conceptual tools to describe, understand, and take into account the critical elements in collaborative knowledge-advancing inquiry (Hakkarainen and Sintonen 2002; Muukkonen et al. 2008). The approach of project-based learning allows students to explore their own interests, thus nurturing their individual strengths and enthusiasm in project work (Blumenfeld et al. 1991; David 2008; Marx et al. 1997; Thomas 2000). This is found to be effective in stimulating learners to actively engage in information search and data evaluation (Prince and Felder 2006). The possibility to combine it with a form of inquiry learning is a promising learning strategy (Chu 2009; Krajcik et al. 1998) to achieve the positive instructional outcomes proposed by the model. This form of integration, called inquiry PjBL, combines constructivist principles with the idea of providing support to individuals through working on and extending their development.

4.1.2 Supporting Science Education with the Use of Technology

In the area of science education, IBL and PjBL have been shown to support cognitive abilities like critical thinking and reasoning, and the acquisition scientific knowledge (Olson and Loucks-Horsley 2000). Students are actively engaged in a learning process shaped by inquiry, which resembles scientific inquiry and implicitly mediates scientific skills (Anderson 2002). However, for the successful deployment of a learning environment, it is vital to include the use of various tools and learning structures that enhance and facilitate students' adaptation to it. Hmelo-Silver et al. (2007), for instance, place emphasis on scaffolding with respect to task structuring and the externalization of disciplinary thinking and strategies. Edelson (2001) illustrated the advantages of the use of technology in science education. He introduces a technology-supported inquiry learning approach and depicted the learning cycle that involves motivation, knowledge construction, and knowledge refinement. This incremental construction process can be regarded as a way of translating the inquiry process used by scientists to advance human understanding into a process that can be adopted by teachers and students to "strengthen students' understanding" (Edelson 2001, p. 360).

There are several ways in which technology enhances scientific inquiry learning. First, experiments and practical work can be done in virtual laboratories. A literature review of 135 empirical studies in the ERIC (Education Resources Information Centre) database and PsychInfo shows that visualization of experiments helps

students overcome conceptual errors by making explicit the links between information and facts (Wu and Shah 2004). It was found in Greece that students had better academic performance and a more positive attitude toward Physics courses that integrated the use of digital simulation tools in laboratory work (Baltzis and Koukias 2009). A study conducted in Cyprus also revealed that the use of simulations together with real experimentation strengthened students' understanding of scientific concepts, when compared to the approach of using real experimentation alone (Zacharia 2007). Students carried out experiments, either guided by a teacher (Donnelly et al. 2013) or in a self-directed manner (Kluge 2014; Liu 2006). In the study done by Donnelly et al. (2013), Irish secondary school students were given the freedom to design their own experiments under the teacher's guidance. Teachers reported that students were able to carry out the experiments at their own pace, and were all making an effort to solve the problem at hand by trying out different approaches. In Kluge's study (2014), upper secondary students in Norway completed a Biology group project with the assistance of a digital laboratory. They were required to design the experiment using the digital platform, discuss the results, and present them to their peers. Analysis of students' performance suggested that engaging them in post-experimental work is instrumental in helping them associate the results of experiments with the relevant scientific theories.

The aforementioned simulations have often been reported to be applied in class. Apart from classroom use, students may benefit from technology use outside the classroom. For example, a collaborative learning environment named "smart classroom" has been codesigned by scholars and Physics teachers to hone students' collaborative problem-solving skills in Canada (Tissenbaum et al. 2012). The collaborative learning environment made use of Web 2.0 technology, enabling teacher–student and student–student interaction both in and outside the classroom through a series of in-class exercises, homework, and take-home group tasks. Before class began, the platform generated aggregate reports on students' performance to support teachers' lesson planning. During class, student responses to questions were compiled and shown on a large projected display. This facilitated teachers' understanding of student knowledge and allowed them to give specific feedback. Group take-home assignments done on the platform were also observed to help develop students' collaboration skills. The study results indicated that access to peer work was a great resource and effective in students' sense-making. Teachers in the United States were also noted to benefit from the student-generated content, as they were able to see patterns in student responses in order to engage them in more in-depth class discussions and to clear misconceptions (Hake 1998).

4.1.3 European Policy Concerning Twenty-First Century Skills

After introducing different models of science education and ways in which technology can support science education, this section examines the significance of

acquiring twenty-first century skills in the European context. The European e-Competence Framework 3.0, a part of the European Committee for Standardization, has created a reference of 40 competences as required and applied it at the Information and Communication Technology (ICT) workplace, using a common language for competences, skills, and capability levels that can be understood across Europe (CEN 2013). The framework enables the identification of skills and competences that may be required to successfully perform duties and fulfill responsibilities related to ICT in both the private and public sectors.

"Structured in four dimensions, the European e-Competence Framework reflects different levels of business and human resources (HR) planning requirements, including job proficiency guidelines" (CEN 2013).

- Dimension 1 embodies five e-competence areas, derived from ICT business processes: Plan, Build, Run, Enable, and Manage.
- Dimension 2 defines a set of e-competences for each area, with reference to definitions for 40 different competences in total.
- Dimension 3 sets out proficiency levels (e-1 to e-5) of each e-competence, which correspond with levels 3–8 in the European Qualification Framework (EQF).
- Dimension 4 provides examples of knowledge and skills that relate to the specific e-competences defined in dimension 2 (CEN 2013).

Within the 40 e-competencies identified in Dimension 2, several competencies fit the general understanding of twenty-first century skills, for instance, innovating, testing, problem management, personnel development, information, and knowledge management, as well as project and portfolio management.

In the communication from the commission to the council of the European parliament, the European economic and social committee and the committee of the regions, the following policies regarding twenty-first century skills were formulated to foster competitiveness and growth in both the public and private sectors (CEN 2013).

– **Longer term cooperation**: solidifying cooperation between public authorities and the private sector, academia, unions, and associations through the advocacy of multistakeholder partnerships and joint initiatives including monitoring supply and demand, anticipating change, adapting curricula, attracting foreign students, and highly skilled ICT workers and promoting ICT education on a long-term basis.
– **Human resources investment**: ensuring sufficient public and private investment in human resources and e-skills, and appropriate financial support and fiscal incentives, in full respect of State aid rules, as well as developing an e-competence framework and tools facilitating mobility, transparency of qualifications, and promoting recognition and credit transfer between formal and nonformal and industry ICT education and certifications.

The following section will provide an example of an inquiry-based learning project using a participative technology named ABAHCOCOSUCOL, an action and participation method based on collaboration among learners (Notari 2006). This

project-based learning approach for higher secondary education addresses the skill sets proposed by the European Community, focusing on problem management, personnel development, information and knowledge management, and project and portfolio management.

4.2 An Example of a Project-Based Inquiry Learning Approach in Switzerland Using Wiki as a Co-authoring and Collaboration Tool

4.2.1 Implementation Model

The implementation of the scenario follows the ABAHCOCOSUCOL (Action BAsed, Hypertext—COnstructive, COmputer SUpported, COllaborative Learning) method of collaboration using wikis (Notari 2006). It was developed in order to help teachers design an appropriate inquiry-based collaborative learning environment and scaffold students' activities during the active learning phases. ABAHCOCOSUCOL is based on the progressive inquiry model proposed by Hakkarainen and Sintonen (2002) and Muukkonen et al. (2008). This methodological approach is designed for use in formal learning settings with high school students as the target audience. The method has not been used in environments with students of an education level lower than grade 8 (Notari 2003).

Scripting for ABAHCOCOSUCOL consists of four phases: (1) Creating content using a hypertext, (2) Linking concepts, (3) Comparing and peer-commenting, and (4) Regrouping concepts within the hypertext. The initiation phase leads students into the problem and gives them an indication for an appropriate first action. In this phase, there is no big difference between ABAHCOCOSUCOL and "conventional" teaching. Learners receive an introduction to the subject by the teacher and start creating the hypertext-content either individually or in small groups. It is crucial that enough content (called 'critical mass of input') is created in the first learning phase. The comparison phase should start immediately after the critical mass of input has been established. Within the comparison phase, learners are invited to read the work of their peers and then to find and link similarities within the created content. The learners can compare immediately and simultaneously the content created by their peers. Such a comparison of ongoing work within a learning community is difficult to realize in a traditional (noncomputer supported) curriculum. Being aware of all other forms of inputs of the community, an individual learner can compare the quality of his/her contribution with that of other contributions, get a formative evaluation of his/her work, and enhance social competences and metacognitive skills through commenting on others' tasks. The feedback and comment culture described above leads to a regrouping of the content. Students then proceed to the regrouping of the work produced, which aids in the

construction of mental models of the different concepts and is fruitful for learning. This sets the stage for the discussion phase. It needs to be stressed that these phases can be repeated more than once. At the end of the learning unit, a discussion should give students the opportunity to formulate and discuss different opinions or concepts. The positive feedback cycle of production, comparison, and regrouping can also be formulated as shown in Fig. 4.4.

The term scripting describes teachers' activities with students and with the wiki. Scripting should facilitate students' publication of what they have produced as soon as possible, with an "evolution" of the content within the unit as a response to the comments and questions of the other members of the community. Although further input can be created during the learning unit, for instance, when new questions arise, the "critical mass" of input at the beginning is essential to initiate interactions among students and the creation of a communication culture. The linking of concepts is salient for raising students' awareness of the common goal and the cross-linkage of the concepts of the unit covered. The learning community co-constructs one collaboratively elaborated hypertext where the different pages are interwoven and linked. Creating links sustains the awareness of the community and gives a basis for the comments and comparisons produced as further actions of the students. Finally, the distillation and regrouping of relevant information lends itself to self-evaluation of the product of the learning community.

The principal settings of ABAHCOCOSUCOL can be used for a wide range of educational purposes. They are not bound to a specific school subject or to a learning environment where students and the teacher see one another regularly. The major advantages of the model include the quick setup when the model is applied using a wiki, the considerable adaptability and the scalability of the system. ABAHCOCOSUCOL has been adopted with high school students in different nonexperimental learning settings and in a blended distance education course about media methodology with adults. Applications of ABAHCOCOSUCOL have shown good learning performances concerning the following competences and skills:

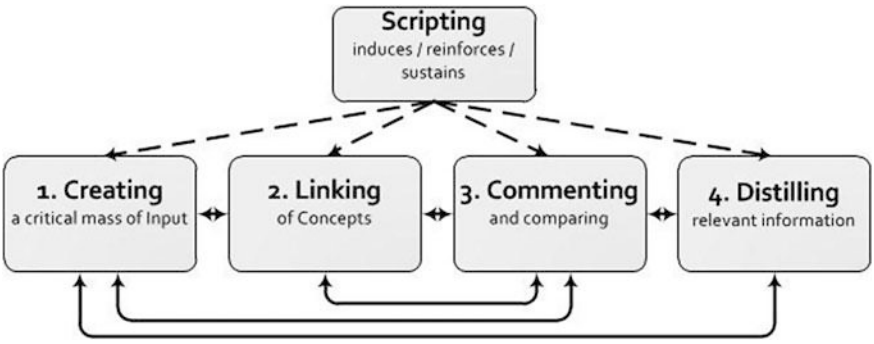

Fig. 4.4 ABAHCOCOSUCOl method (reproduced from Notari 2006)

increase of factual knowledge, long-term knowledge retention and metacognitive skills, development of problem-solving strategies, ability to construct a hypertext, link concepts, and distil relevant information to regroup concepts (Notari 2003).

4.3 Case Study: Creating a Collaborative Glossary in Science Education: "Evolution"

Entrusting learners with the task of creating or cocreating a glossary of the learning topic helps them better remember core elements and concepts and enhance their vocabulary, writing skills, and semantic skills (Schneider et al. 2004, p. 28). Schneider describes six steps for making the glossary:

1. "The teacher and students identify and determine the terms to be defined related to a theme they do not master.
2. The alphabetical list of terms to be defined is entered in the interactive space chosen.
3. Students search the web or in dictionaries resources on the theme.
4. Students synthesize their results to create short definitions.
5. The teacher checks if the definitions are right.
6. Students enter their definitions".

Collaborative glossaries can be compiled using different technological tools. Moodle (a learning management system) offers a specific module (glossary Module, see https://docs.moodle.org/26/en/Glossary_module) where learners of the same course can access the same page and have equal rights to edit and change content of the page. Notari and Doebeli (2012) chose a Wiki to set up a collaborative glossary scenario for biology education at high school level. The created collaborative glossary was used for a learning community of two classes working simultaneously on the same topic with the same teacher. The collaborative glossary was part of a learning unit which was an introduction to evolutionary biology. The primary goal of the evolution unit was for students to get an overview and understand different abstract concepts. Evolution is part of the Biology curriculum of 11th grade high school students in Switzerland. Students at that age already have fundamental knowledge of genetics, taxonomy, and the development of species but the concept of a scientific theory has never been previously mentioned. The abstract definition of the theory—the validity of hypotheses—is retained until one of the hypotheses is proven to be false. It is difficult to separate the term "theory" from belief. As students have learned the basic concept of the possible origin of living organisms and the way genetic information is passed on from one generation to the next, they can imagine how genetic information itself, and through it, life can survive through time. This way of looking at the possibility of survival of genetic information from an organism through time could lead to a hypothesis about evolution of organisms.

4.3.1 Time Schedule, Group Building

The unit spanned across four lessons (180 min) for each class. Before the start of the unit, about one-and-a-half lessons were spent introducing the tool. The students had two periods of lesson time to complete learning tasks assigned to them.

4.3.2 Specific Goal

The chief aim of the learning unit was to create a collaborative glossary with the definitions of the pertinent terms related to evolution, to link all the similar concepts and to re-group different terms under specific categories.

4.3.3 The Collaborative Glossary

As illustrated in Fig. 4.5, after a short description of the unit, the different goals and the wiki, the participants were instructed to search for terms concerning evolution. Then they had to write a comprehensive definition of the term and publish it on the wiki. A second task was to search through the definitions written by the other students and find similar terms. These terms then had to be linked to their own definition. A third task was to group similar definitions, e.g., names of researchers such as Darwin, Lamarck, Cuvier, etc. After the first contact with the tool, students began to formulate definitions and create new pages. The project team tried to correct mistakes in the definitions. They read the texts written by the students, gave feedback and assisted them with the literature search and research on the Web. Students were advised to cite all the input and to make references to the literature or the Website where they found the information and were reminded to keep their definitions short and concise.

The project team encouraged students to give their own definitions for the terms, as the goal of creating the dictionary was to construct definitions adapted to their state of knowledge. Many definitions found on the Web were too complicated and full of unfamiliar words. At the beginning, students merely copied the definitions they managed to find. After a while they showed more and more attempts to adapt the definitions they found or at least to explain all the foreign words and difficult sentences. After the first two lessons, the project team reinforced the linking of concepts. Students were presented with the task of searching for similar words and definitions and trying to link them to other concepts. They were also told to complete definitions or to add definitions of terms whenever necessary as they read the texts. The team created opportunities for the students to group similar terms on the starting page and build new categories of terms, for instance, by putting all the names of researchers under a category.

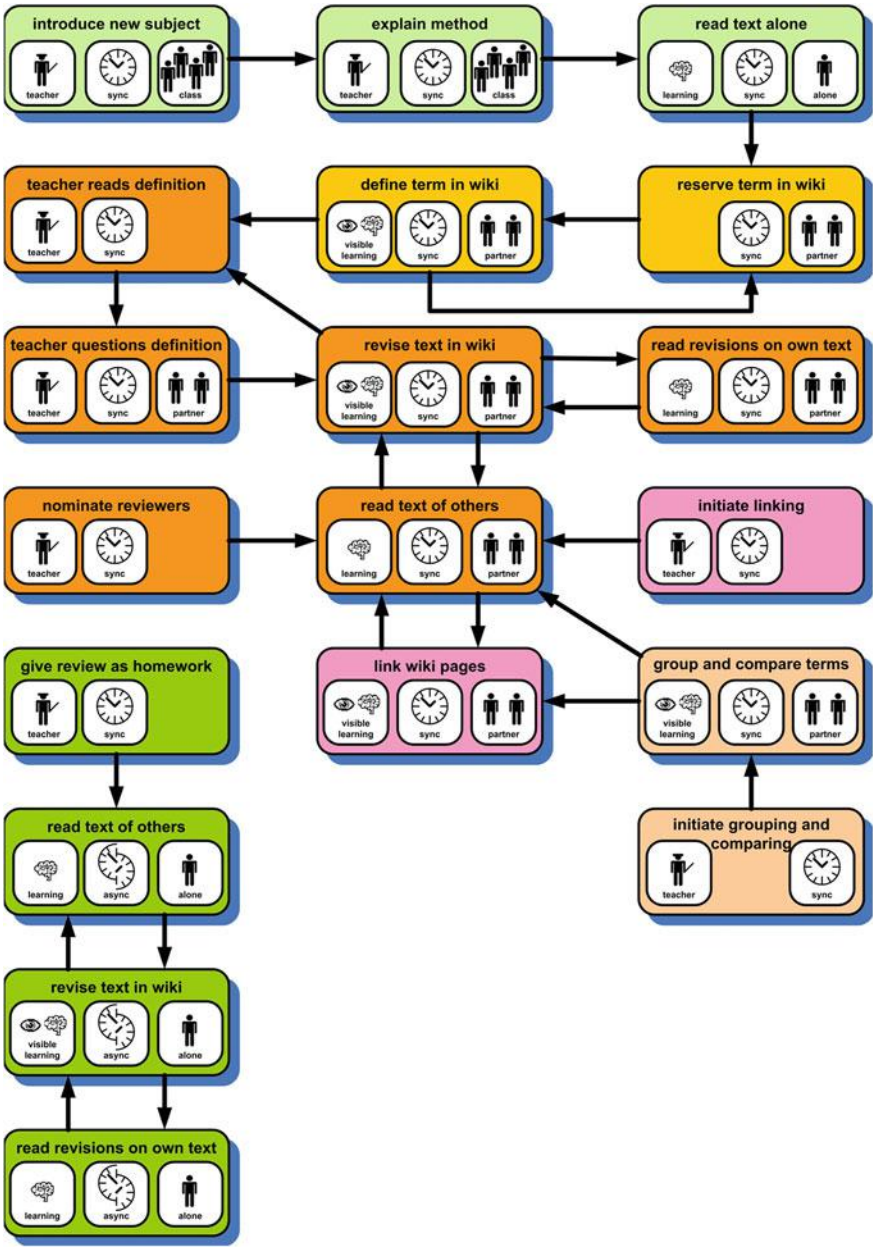

Fig. 4.5 Collaborative glossary "evolution" (reproduced from Notari and Doebeli 2012)

The mass of collaborative hypertext grew exponentially. At the beginning of the course, students mainly copied definitions of scientific terms from the Internet randomly without truly understanding what they had posted. Students were asked to read other definitions as homework, and to pose questions if they did not understand terms or sentences. At the start of the second lesson, it was announced to the students that all definitions had to be learned for the final assessment. Given this input, the contents of the definitions changed dramatically and the amount of questions of the readers increased and became more precise and pertinent.

Three different formative evaluation elements were implemented within the curriculum. The wiki allowed students to see the work in progress of all learning groups. They were advised to periodically read and comment on the contributions of other members in the community. At the initial stage, they reported feeling uncomfortable making comments on the produced artifacts of other groups. Similar results were recorded in comparable studies in Asia where sociopsychological factors such as conformity were observed where students expressed contradictory views (Venkatesan et al. 2014). As students progressed further in the project, the comments became more and more structured and also diversified. In the second phase, the project team urged them to link similar concepts of the created artifacts. The teaching team wanted them to find conceptual similarities and raise their awareness of connections between the created definitions within the glossary. In the subsequent formative evaluation, students were instructed to group and re-group definitions in order to build new categories of terms. This intervention was introduced in order to enhance students' higher order thinking skills. Peer-evaluations were involved but teachers also gave feedback on students' work and suggested possible links between related content and assisted with the regrouping of concepts in the glossary.

On the whole, the project-based curriculum was found to be beneficial in enhancing students' inquiry capacities. Through working on the project and managing their portfolios, students sharpened their information research skills, especially in retrieving relevant content from the identified digital artifacts. They also showed gains in their problem management, information and knowledge management skills.

4.4 Conclusion

This chapter provides a literature review on concepts and models of science education in Europe and documents a case study that illustrates the advantages of technology-enhanced collaborative Biology learning and its impact on facilitating the development of twenty-first century skills among secondary students in Switzerland. The findings of the case studies support the use of technology-enhanced inquiry-based science learning as a promising teaching and learning approach. Such an approach is expected to be most effective when social media technologies are utilized in an appropriate way and teachers use adaptive strategies

to scaffold student collaboration and guide them in fruitful knowledge creation. Applying the inquiry-based model proposed by Hakkarainen and Sintonen (2002) and Muukkonen et al. (2008), as well as the ABAHCOCOSUCOL method advocated by Notari (2006), we cited examples of how science can be taught to twenty-first century learners and how wiki-based technology can raise students' competences in the subject matter and aid formative evaluation of student work and progress.

Science education offers different opportunities for teachers to incorporate technology into the learning process. Technology can be used for measuring parameters like temperature, weight, and electrical power or with more powerful tools with multiple sensors. Some modern equipment even allows such changes to be visualized, and values and diagrams to be exported for further processing. This usage of technology in science education is beyond the scope of the present chapter. The chapter focuses on a higher level of technology integration, namely how to set up and manage collaborative platforms using appropriate models and methods. Teachers' major concerns in using technology, especially wikis, arise from their insecurity about the quality of the created artifacts, that not every student learns exactly the same content and may not participate equally in content creation, as well as their fear of not having sufficient IT skills to prevent loss of data (König and Hodel 2013). The examples included show how such pitfalls can be minimized and how twenty-first century skills can be taught not only in science education but also in all other topics from primary school to university level.

References

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*(1), 1–12.

Baltzis, K. B., & Koukias, K. D. (2009). Using laboratory experiments and circuit simulation IT tools in an undergraduate course in analog electronics. *Journal of Science Education Technology, 18*, 546–555.

Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist, 26*(3&4), 369–398.

CEN (2013). *European e-competence framework 3.0 brochure*. Retrieved May 11, 2015 from http://www.ecfassessment.org/uploads/documenten/9/CEN_e_CF_3.0_brochure.pdf/

Chu, S. K. W. (2008). TWiki for knowledge building and management. *Online Information Review, 32*(6), 745–758.

Chu, S. K. W. (2009). Inquiry project-based learning with a partnership of three types of teachers and the school librarian. *Journal of the American Society for Information Science and Technology, 60*(8), 1671–1686.

David, J. (2008). What research says about project-based learning. *Educational Leadership, 65*, 80–82.

Donnelly, D., O'Reilly, J., & McGarr, O. (2013). Enhancing the student experiment experience: Visible scientific inquiry through a virtual chemistry laboratory. *Research in Science Education, 43*(4), 1571–1592.

Edelson, D. C. (2001). Learning-for-use: A framework for the design of technology-supported inquiry activities. *Journal of Research in Science Teaching, 38*(3), 355–385.

Fischer, H., Neumann, K., Labudde, P., & Viiri, J. (2014). Theoretical framework. In H. Fischer, K. Neumann, P. Labudde, & J. Viiri (Eds.), *Quality of instruction in physics—comparing Finland, Germany and Switzerland* (pp. 13–30). Münster: Waxmann.

Fung, K. Y., Chu, S. K. W., Tavares, N., Ho, G., & Kwan, K. (2011). *Using Google sites in English collaborative writing*. In CITE Research Symposium 2011. Hong Kong: The University of Hong Kong.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 66*(1), 64–74.

Hakkarainen, K., & Sintonen, M. (2002). The Interrogative model of inquiry and computer-supported collaborative learning. *Science & Education, 11*(1), 25–43.

Hammann, M. (2006). Naturwissenschaftliche Kompetenz – PISA und scientific literacy. In U. Steffens & R. Messner (Eds.), *PISA macht Schule. Konzeptionen und Praxisbeispiele zur neuen Aufgabenkultur* (pp. 127–179), Wiesbaden: Hessisches Kultusministerium.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist, 42*(2), 99–107.

König, A. & Hodel, J. (2013). Wiki im Geschichtsunterricht der Sekundarstufe 2. *Der Wiki-Weg des Lernens*. (Notari & Döebeli, eds.) hep, Bern

Kluge, A. (2014). Combining laboratory experiments with digital tools to do scientific inquiry. *International Journal of Science Education, 36*(13), 2157–2179.

Krajcik, J., Blumenfeld, P. C., Marx, R. W., Bass, K. M., Fredricks, J., & Soloway, E. (1998). Inquiry in project-based science classrooms: Initial attempts by middle school students. *Journal of the Learning Sciences, 7*, 313–350.

Kuhlthau, C. C. (2004). *Seeking meaning: A process approach to library and information services*. Cincinnati: Libraries Unlimited Inc.

Kuhlthau, C. C. (2010). Guided inquiry: School libraries in the 21st century. *School Libraries Worldwide, 16*(1), 17–28.

Kuhlthau, C., Maniotes, L., & Caspari, A. (2007). *Guided inquiry: Learning in the twenty-first century*. Westport, CT: Libraries Unlimited.

Labudde, P. (2003). Faecheruebergreifender Unterricht in und mit Physik: Eine zu wenig genutzte Chance. *Physik Und Didaktik in Schule Und Hochschule, 1*(2), 48–66.

Labudde, P. (2008). The role of constructivism in science education: yesterday, today, and tomorrow. In Silke Mikelskis-Seifert (Ed.), *Four decades of research in science education: From curriculum development to quality improvement* (pp. 139–169). Münster: Waxmann Verlag.

Labudde, P., & Adamina, M. (2008). HarmoS Naturwissenschaften: Impulse für den naturwissen schaftlichen Unterricht von morgen. *Beiträge Zur Lehrerbildung, 26*(3), 351–360.

Labudde, P., Heitzmann, A., Heininger, P., & Widmer, I. (2005). Dimensionen und Facetten des fächerübergreifenden naturwissenschaftlichen Unterrichts: ein Modell. In K. Neumann & S. Rumann (Eds.), *Zeitschrift Fuer Didaktik Der Naturwissenschaften* (pp. 103–115). Berlin: Springer.

Labudde, P., Reif, F., & Quinn, L. (1988). Facilitation of scientific concept learning by interpretation procedures and diagnosis. *International Journal of Science Education, 10*(1), 81–98. doi:10.1080/0950069880100108.

Liu, X. (2006). Effects of combined hands-on laboratory and computer modeling on student learning of gas laws: A quasi-experimental study. *Journal of Science Education and Technology, 15*(1), 89–100.

Mak, B., & Coniam, D. (2008). Using wikis to enhance and develop writing skills among secondary school students in Hong Kong. *System, 36*(3), 437–455.

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., & Soloway, E. (1997). Enacting project-based science: Challenges for practice and policy. *Elementary School Journal, 97*, 341–358.

Miller, J. D. (1983). Scientific literacy: A conceptual and empirical review. *Daedalus, 112*(2), 29–48.

Muukkonen, H., Lakkala, M., & Hakkarainen, K. (2008). Technology-enhanced progressive inquiry in higher education. In M. Khosrow-Pour (Ed.), *Encyclopedia of information science and technology I-V* (2nd ed., pp. 3714–3720). Hershey, PA: Idea Group Inc.

Notari, M. (2003). Scripting strategies in computer supported collaborative learning environments. In A. Méndez-Vilas, J. A. Mesa González & J. Mesa González (Eds.), *Advances in technology-based education: Towards a knowledge based society. Proceedings of the II International Conference on Multimedia and Information & Communication Technologies in Education,* Vol. II. Badajoz, Spain.

Notari, M. (2006). *How to use a wiki in education: Wiki based effective constructive learning*. Retrieved May 11, 2015 from http://www.wikisym.org/ws2006/proceedings/p 131.pdf

Notari, M., & Doebeli, B. (2012). Wiki: an archetypical tool for collaborative learning in the digital age. In S. Bocconi & G. Trentin (Eds.), *Wiki supporting formal and informal learning* (pp. 21–40). New York: Nova Publishers.

Notari, M., Baumgartner, A., & Herzog, W. (2014). Social skills as predictors of communication, performance and quality of collaboration in project-based learning. *Journal of Computer Assisted learning, 30*(2), 132–147.

Olson, S., & Loucks-Horsley, S. (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington: National Academies Press.

Piaget, J. (1970). Piaget's theory. In P. H. Mussen (Ed.), *Carmichael's manual of child psychology* (pp. 703–732). New York: Wiley.

Prince, M. J., & Felder, R. M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of Engineering Education, 95*(2), 123–138.

Ramseier, E., Labudde, P., & Adamina, M. (2011). Validierung des Kompetenzmodells HarmoS Naturwissenschaften: Fazite und Defizite. *Zeitschrift Fuer Didaktik Der Naturwissenschaften, 17*, 7–33.

Schneider, D. K., Chakroun, M., Frete, C., Girardin, F., Morand, S., & Morel, O. (2004). Tecfa seed catalogue. http://tecfa.unige.ch/proj/seed/catalog/net/catalog-eng.pdf

Tavares, N., Chu, S. K. W., & Weng, M. (2011). Experimenting with English collaborative writing on Google Sites. *Paper presented at CITE Research Symposium 2011*. Hong Kong: The University of Hong Kong.

Tissenbaum, M., Lui, M., & Slotta, J. D. (2012). Co-designing collaborative smart classroom curriculum for secondary school science. *J. UCS, 18*(3), 327–352.

Thomas, J. W. (2000). *A review of research on project-based learning*. San Rafael, CA: Autodesk Foundation.

Venkatesan, H., Biuk-Agai, R., & Notari, M. (2014). Collaborative learning of translation: The case of Macao. In *Proceedings of the 9th International Symposium on Open Collaboration, WikiSym' 2014*, Hong Kong.

Widodo, A., & Duit, R. (2004). Konstruktivistische Sichtweisen vom Lehren und Lernen und die Praxis des Physikunterrichts. *Zeitschrift Fuer Didaktik Der Naturwissenschaften, 10*, 233–255.

Woo, M., Chu, S., Ho, A., & Li, X. (2011). Using a wiki to scaffold primary-school students' collaborative writing. *Journal of Educational Technology & Society, 14*(1), 43–54.

Wu, H. K., & Shah, P. (2004). Exploring visuospatial thinking in chemistry learning. *Science Education, 88*, 465–492.

Zacharia, Z. (2007). Comparing and combining real and virtual experimentation: an effort to enhance students' conceptual understanding of electric circuits. *Journal of Computer Assisted learning, 23*(2), 120–132.

Chapter 5
Twenty-First Century Skills Education in the U.S.: An Example of an Inquiry-Based Game Design Learning Approach

In today's society, being a citizen and engaging in a participatory democracy largely require sustained technology access, use and skills to take part productively and effectively in economic and political activities (Mossberger et al. 2007). Adequately preparing our current students for success in the workforce also calls for their development of such technology-related skills. For instance, high job growth sectors in the U.S. include professions in the computing and information sciences, which, according to the U.S. Bureau of Labor Statistics, will soar in number through 2018 at more than twice the rate of all other STEM disciplines combined (Lacey and Wright 2009). In response to these realities that stem from the evolution of computing technologies and their increasing role as tools and media supporting our lives and livelihood, the National Education Technology Plan (US Department of Education 2010) and U.S. National Broadband Plan (NBP) of the *Federal Communications Commission* (FCC) have established educational technology, digital literacy, participatory culture and digital divide concerns as key target areas of national education policy agenda (e.g., Hobbs 2010; Horrigan 2011; Jenkins 2009; Mossberger et al. 2007).

Despite such policy guidelines, research indicates that an inequality of digital skills exists among the U.S. population, which has come to be known as the digital divide—the gap between those who have and effectively use technology, and others who do not (OECD 2006). Cross-sectional research in the general population indicates that even among those with moderate to high levels of technology access, more sophisticated forms of content creation, participatory engagement and digital knowledge have been associated with higher socio-economic status and level of education (Pew Internet and American Life Project 2007). In other words, the higher the level of education, the greater the self-reported digital skill. Furthermore, those with better levels of self-reported skill are more likely to visit the types of websites that stand to benefit their cultural and financial capital (Hargittai and

S.K.W. Chu et al., *21st Century Skills Development Through Inquiry-Based Learning*, DOI 10.1007/978-981-10-2481-8_5

Hinnant 2008). Those from more privileged backgrounds use Web-based technologies in more informed ways for a larger number of activities, revealing that socio-economic status, race and gender predict digital literacy in ways that may influence social mobility (Hargittai 2010).

Interestingly, despite clear intersections, the related corpuses of social sciences research on the digital divide, and educational technology research investigating students' social constructivist and inquiry-based learning with technology, are not commonly bridged. Inquiry-based learning innovations with technology have the potential to advance learning in the core content domains described thus far in this book. Specifically, inquiry-based learning approaches have much to contribute to the discussion on addressing the digital divide, and the pragmatic achievement of alleviating this social problem. If such approaches are well-designed and implemented, and adopted more widely and equitably in the full range of diverse U.S. public schools, this will extend important technology learning opportunities more equitably, in what could amount to a closing of digital divide gaps, and greater social mobility among diverse populations.

5.1 Technology Education in the United States

In this section, we outline the education policy and national association standards' landscape with regard to educational technology innovation in the U.S., highlighting academic research in the field of the learning sciences as well as developments in industry. We discuss existing research on some smaller scale guided inquiry-based learning projects, and identify opportunities for expanding the evidence base of program evaluation research in the area of educational technology effectiveness, to help educators make research-driven decisions on what works.

5.1.1 Policies and National Standards, and Implementation Challenges

A number of national level policy initiatives in the U.S. have proposed guidelines on technology education. The 2010 National Education Technology Plan (NETP) recommends wide-reaching technology educational efforts in schools to support teaching/instruction, and student learning (2010), leading to the need for quite radical transformation in each of the following areas:

- Learning: Engage and Empower
- Assessment: Measure What Matters
- Teaching: Prepare and Connect

- Infrastructure: Access and Enable
- Productivity: Redesign and Transform
- Research and Development: Innovate and Scale.

Addressing inequalities in digital access and infrastructure across the U.S. population, the FCC's National Broadband Plan offers recommendations such as reduced-rate broadband for certain market sectors, and expansion of digital literacy education to promote not just technology access but greater sophistication of uses among the general public, starting at an early age (NBP 2010; Horrigan 2011).

Moreover, national association standards such as the American Association of School Librarians' (AASL) 2008 Standards for the Twenty First Century learner, and the International Society for Technology in Education's (ISTE) 2008 National Education Technology Standards recommend and advocate school-based delivery of educational technology programs that will cultivate students' technology expertise and dispositions toward active, constructive and creative technology uses. The AASL has embarked recently to update its mission, identifying three key factors that are transforming school librarianship, largely driven by technology:

1. The role of the school librarian is evolving and changing to serve as the guiding light in transforming learning through new tools and technology;
2. The essence of school libraries is teaching and learning; and
3. The AASL must work with leaders, within and outside our profession to voice and contribute to the transformation process.
   (AASL Press Release, July, 2014)

While standards in national association frameworks have been updated to consider youth engagement in the era of social media technologies and students' capacity to develop, create, contribute and publish content of their own, such policy documents often neglect to offer specific, concrete and pragmatic recommendations about *how* schools and teachers may achieve the skills outcomes they specify. Test score accountability in the core curriculum can result in a "doing fewer things better" approach among K-12 administrators and their faculties, sidelining technology integration. Teachers are unclear about how technology and engineering/computer science efforts (the T and E of STEM) can be integrated effectively into the core disciplines, or offered as separate classes, within already full block schedules. Norris and Soloway (2011) identify the following barriers to technology adoption by teachers: lack of clarity on effective uses, lack of money or leadership support, school leaders' prioritization of test-driven accountability goals, and need for clearer assessments. Wellings and Levine (2009) further point out the dilemma of innovation outpacing research as a hurdle for school educational technology decision-makers. They assert that research eliciting clear pragmatic findings for effective technology integration practice is sorely needed.

Massive open online courses (MOOCs) and online learning platforms present opportunities for teachers' professional development in educational technology integration, both for free online and at an affordable cost to school districts. Most U. S. states have an organizational association or state department of education affiliate

group that issues continuing education credits for pre-approved professional development opportunities. Nevertheless, sanctioned opportunities for teachers supporting the integration of technology vary widely from state to state.

Of note, a 2013 report published by the National School Boards Association's Center for Public Education critiques the typical cross-sectional, short-term workshop format of most teacher professional development in the U.S. context (Gulamhussein 2013). The report notes that single session workshops often do not change teacher practice and have little effect on student achievement (Yoon et al. 2007). The rationale for these discouraging results is that such workshops do not have a positive impact on teachers during the implementation stage of learning—that which has the steepest learning curve for them. Educators still struggle to find time to partake in such resources and update their pedagogy to leverage technology affordances. In spite of efforts such as E-Rate (officially called the Schools and Libraries Program of the Universal Service Fund of the FCC, established in 1997 to give schools and libraries discounts on technology infrastructure), funding for maintaining and updating technology infrastructure in schools and libraries in the U.S. also remains an issue—consider, for instance, the 2011 defunding of Enhancing Education Through Technology (EETT) program, which was initially funded at $700 million annually but dropped to $100 million by 2010, and is now defunct (EdWeek 2011).

The launch of the new National Education Technology Plan of 2016 offers some hope, as does the U.S. president Barack Obama administration's "Future Ready" initiative of 2014 which gives school district administrators resources and networking opportunities among one another to accelerate the transformation of their schools through effective use of digital learning strategies. Below we will outline a range of implementation strategies in detail, derived from an organization called Globaloria, which provides administrators, educators, and students an in-depth program of project-based game design learning, including an enriched online learning environment for students and classes, full curriculum for in-school implementation as a daily class, ongoing frequent trainings for teachers in-person and through online webinars (situated in the real-time curriculum sequence they are teaching at that moment), and many other supports. Our discussion focuses on their offerings circa 2012/2013; the program continues to evolve each year and has expanded its offerings substantially further. Educators are encouraged to find and connect with organizations like Globaloria to acquire ongoing expert guidance and support, so they are not "going it alone."

5.1.2 Smaller Scale Pilots of Instructional Design Innovations

Research on learning technology innovations began more than 40 years ago, with research goals, theories and methods evolving and branching over the years (Marshall and Cox 2008; Voogt and Knezek 2008). Early on, researchers focused

mainly on enhancing individual students' learning of specific concepts or skills. The field gradually expanded attention to the broader picture of teacher beliefs, motivation for technology use, and teacher pedagogical practices (Passey et al. 2003; Law et al. 2008; Meyer et al. 2011), as well as the impact of technical affordances in the learning environment (Hennessey and Deaney 2004) and the formality of the setting (more or less structured) (Mumtaz 2001). Importantly, the field also grew to address the effect of specific factors on students' learning of concepts and skills (Crook 1997; Yeh et al. 2011). As technology has evolved, technology features and affordances for education have also transformed in kind, as have research methods and data practices (Marshall and Cox 2008), for instance, the expansion in using observations of students' online activities, as well as learning analytics data such as trace logs to understand student learning processes (Rodríguez et al. 2010), as well as teachers' practices (Fisher et al. 2012).

In the fields of the "learning sciences" and "computer science education," researchers are using rigorous social science and educational psychology research methods to investigate technology-based learning innovations and instructional approaches. The learning sciences is an interdisciplinary field that works to advance scientific understanding of learning, and to contribute towards the design and implementation of learning innovations, and the improvement of instructional methodologies (Sawyer 2005). Similar to the theoretical underpinnings of the inquiry-based approaches discussed in earlier chapters, education contexts being studied in learning sciences research are often guided by constructivist, social-constructivist, socio-cognitive, and socio-cultural theories of learning (2005). Research is conducted on projects administered both within and outside classrooms, and in the standard core disciplinary knowledge domains, as well as newer K-12 academic subject areas such as computer science, computational thinking and information/digital/media literacies.

In such contexts, learning technology innovations developed by the researchers are often tested, refined and iterated among smaller sized samples of learners. Funding for the development of such innovations (and commercialization in some cases) stems from sources such as the National Science Foundation, which sponsors programs such as Cyberlearning and "Broadening Participation in Computing" (BPC), tailored to support such advancements. For instance, The Georgia Computes! Project was a National Science Foundation BPC award winner spearheaded by Georgia Tech's College of Computing in cooperation with the Georgia Department of Education, and focused on increasing the number and diversity of computing students in the state of Georgia. This project included an initiative to train high school teachers how to teach computing to their students and generate greater interest in pursuing ongoing computing education, using motivating pedagogical approaches involving design. Private foundations like the John D. and Katherine T. MacArthur Foundation's Digital Media and Learning (DML) initiative has also supported educational technology innovation since its launch in 2006. Such funding initiatives drive advancement of new learning technologies, with an aim to support the scale of these innovations through cultivation of a research evidence base.

5.1.3 Industry Forces as Drivers of Educational Technology Innovations

In addition to communities of researchers exploring and contributing to innovative learning technologies, entrepreneurial industry market dynamics are influencing the field. Technologies facilitating "blended learning" and "distance learning" models as well as MOOCs, have gained much headway among adult learners, and are now moving into the K-12 public school space. A new venture capital market is emerging for startup companies developing innovative educational and learning technologies and curriculum delivery platforms (Watters 2015), and competition for school district budget allocations is escalating among such newcomers and more traditional bricks and mortar publishers.

School district budgets for technology integration initiatives may derive from a mix of three primary funding sources: curriculum budgets (i.e., textbooks), technology infrastructure budgets (sometimes part of a district's "facilities"), and professional development budgets (i.e., teacher training). Striving to maintain their long-standing foothold over these funds, large scale traditional bricks and mortar publishing companies are investing in infrastructure and technology development to enable direct channel delivery of digitized content to U.S. educators via proprietary home-grown solutions as well as acquisitions of start-ups. Commercial learning management system (LMS) providers such as Blackboard, E-College and Schoology are also forging ahead in building content partnerships with publishers, and marketing their web services to K-12 school districts, making strong inroads. Smaller scale educational technology entrepreneurs who launch innovative apps and web services for learning are securing profitable acquisitions by monoliths such as Amazon.com Inc., Scholastic Corp., Pearson or private equity firms with holdings in education and publishing.

Growing industry practices such as these must be considered through a critical lens, as digital distribution of curricular content via commercial LMSs is occurring, but learning effects research is not strongly informing the program development. This ad hoc or arbitrary technology design runs counter to the careful and rigorous research evidence base emerging among technology education research visionaries such as those within the learning sciences community. The proliferation of commercial firms holds an assumption that delivering content digitally will improve educators' pedagogy and students' learning outcomes (without carefully researched design of affordances that meet the needs of the full diversity of learners). Many LMS platforms are catch-all template solutions with generic interfaces that may or may not be customizable. Providers have not considered how design optimization should be tailored with regard to different subject matter, activity type, learning objectives, user population (among both students and teachers), grade levels, etc.

We do not yet have a strong evidence base to indicate under what conditions these information systems add value to learning processes and outcomes, and for what type of learning. Variables to be taken into consideration include student-to-computer

ratios, and student individual differences such as reading level and screen reading preferences (print versus text), and information literacy and online navigational and resource use skills. More research is needed to empower school leaders to make informed and responsible decisions about the application of information systems supporting inquiry, in localized contexts, and given local contingencies.

5.2 Research Cases on Inquiry-Based Learning Through a U.S.-Based Game Design Curriculum, Circa 2012/2013

The following case study summary findings are based on several empirical research studies investigating a learning innovation that facilitates middle school and high school students' game design learning during a single year timeframe of 2012/2013. The program's instructional design demonstrates inquiry-based learning principles discussed throughout the book. The program, called Globaloria, was initiated by a New York City non-profit organization, and as of 2012/2013, was being implemented in middle schools and high schools in five U.S. states. As of 2016, the organization is commercializing, and continuing to grow and expand, and Globaloria courses will be used by 30,000 students and educators in districts and schools in 15 U.S. states. The program's theoretically driven instructional design and the coordinated research efforts along with it serve as an exemplar of the iterative "design-based research" method commonly utilized in the learning sciences field (Disessa and Cobb 2004). The research captured herein provides insights on the learning effects among students who participated in the program, as well as ways in which student inquiry processes guided their learning. The results are situated in the context of current debates in the literature addressing "discovery-based learning" approaches. The findings denote both strengths and limitations of inquiry-based learning, highlighting important questions that are still open in the field as to their effectiveness, and that are being actively addressed in the Globaloria program itself as the system continues to evolve.

5.2.1 Inquiry-Based Game Design Program Features in 2012/2013

In Globaloria, students learn game design using a structured curriculum in which they attend a related class every day, for credit and a grade across an entire school year. Students' creation of a complex digital artifact gives them the opportunity to gain introductory computational thinking and programming experience, while also providing a constructive purpose and context to engage in autonomous inquiry, information resource use, collaboration and problem-solving. During this study's investigation in 2012/2013, students used programming software such as Adobe

Flash, Unity or mobile app development packages depending on the school to create a playable digital web game. The primary goal of the program from the students' perspective is the successful completion of a functioning game.

In-school classes follow a blended learning curriculum daily, for up to 90 min per session, across either a semester or a full year. Students and teachers use a proprietary LMS web service platform developed by the organization. Each participating school gains access to their own project-based learning environment and student/teacher member accounts. The environment contains three types of features:

- Project management features enabling uploading, sharing and archiving of in-progress and final game artifacts;
- Social media features including profile, project and team pages that facilitate communication among classmates as well as collaboration through sharing of game assets; and
- Information resources including the game design curriculum, syllabi, a host of video- and text-based tutorial resources.

Using this platform frequently each day, students engage in both autonomous and collaborative inquiry, information-seeking, and resource uses. The program also requires teacher participation in professional development trainings, on-location and virtual instruction from industry experts, and offers a virtual help desk available during school hours allowing students to contact Globaloria staff in real-time with game design questions.

Figures 5.1, 5.2, 5.3 and 5.4 demonstrate several instructional units of the game design curriculum *as of 2012/2013*. For a full-year implementation, there were a total of six units. During the first three units, working as individuals, students learned introductory programming by creating a simplified "hidden object game"

Fig. 5.1 2012/2013 Globaloria curriculum: list of activities in three out of the six curriculum units for the "Intro to Game Design" course

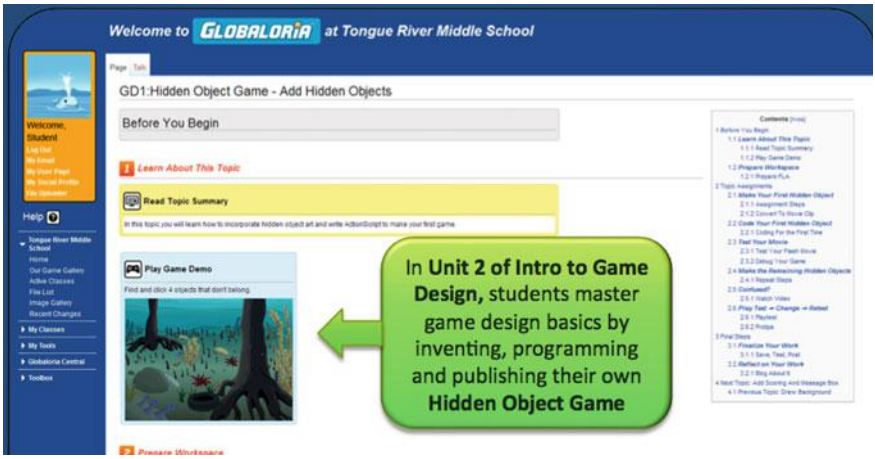

Fig. 5.2 2012/2013 Globaloria curriculum: Screenshot of unit 2 of the learning module

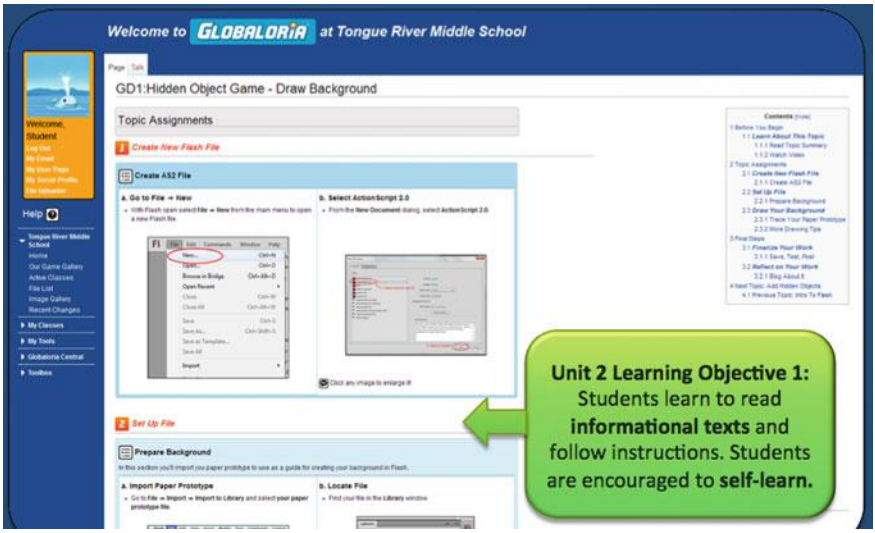

Fig. 5.3 2012/2013 Globaloria curriculum: Screenshot of unit 2 "Learning Objective 1" and adjacent information resource screenshots

and an action game, teaching basic programming fundamentals. They then segue into teamwork in Units 3–6, choosing a more complex game idea in a particular genre such as a platform jumper game, adventure game, or maze. Students are encouraged to develop game themes and a message through online research. At some locations, they may create a game about a particular school subject such as math. In this school year, the first three units were often completed in the first half of the school year, and the latter three in the second half.

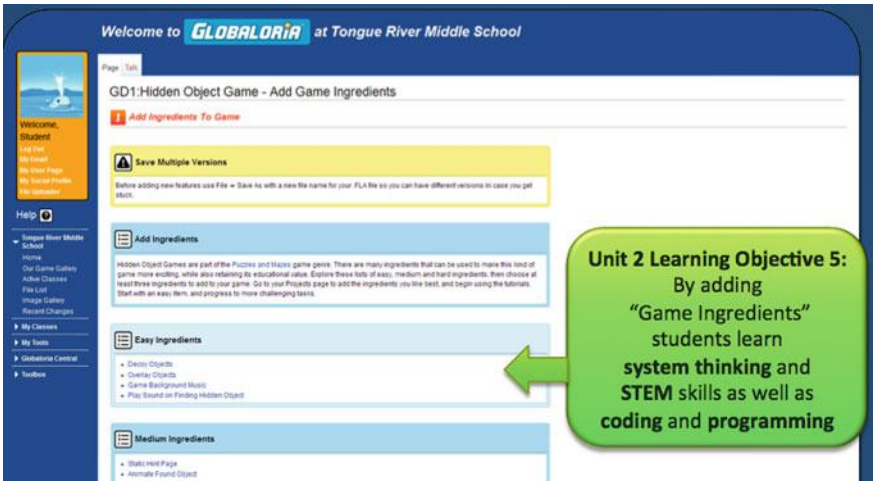

Fig. 5.4 2012/2013 Globaloria curriculum: Screenshot of unit 2's "Learning Objective 5" and adjacent information resource screenshots

The information resources available on the LMS range from text-based tutorial and assignment content to sample programming code, and to video-based step-by-step tutorials, which contain screencast demonstrations of particular programming actions.

5.2.2 Theoretical Underpinnings of Globaloria

The learning theories influencing the design of Globaloria include social constructivism (Vygotsky 1962), and constructionism (e.g., Papert and Harel 1991). Constructionism has been described as a teaching philosophy and "framework for learning and educative action" (Disessa and Cobb 2004) that builds upon Vygotsky's (1962) social constructivist theory and Piaget's constructivist theory. In constructionist learning, students engage in conscious construction of a technologically mediated computational artifact in a workshop-style group educational environment (Papert and Harel 1991; Kafai 1995; Kafai and Resnick 1996). The constructionist approach holds that individuals learn best when mobilizing their entire selves in a personally meaningful pursuit while sensing that their work is valued as part of a larger enterprise (Barron and Darling-Hammond 2008; Stager 2001). Aligning with social constructivism, constructionist interventions are designed to facilitate learners' building of knowledge socially through dialogue and interaction, rather than more top-down approaches involving a sole instructor and a print text. Constructionism adds creation of a computational artifact using programming as a key element (Papert and Harel 1991). The interplay between the

learner's development of a conceptual idea for the artifact and the use of a computational programming language to represent the idea are hallmarks of constructionism, encouraging metacognition, also known as "learning how to learn" (Harel and Papert 1990). Outcomes of such engagement that have been observed and measured among some students (Harel 1991) have included: active, critical thinking; development of greater effort, persistence and self-regulation; confidence and self-efficacy; design principles and aesthetic appreciation; lessons about semiotics as a system of signs and signifiers; meta-level thinking about the nature of semiotics, representations, and other semiotic domains; and core domain knowledge (i.e., math). Harel (1991) also found that after creating designed computational projects representing mathematics principles of fractions, students performed better on mathematics themed standardized knowledge tests than a control group.

Overall, learning in Globaloria occurs through students' constructionist engagement and guided discovery including their interaction with peers and teachers, information resources (in this case, via online LMS), software, and a programming language. These interactions in Globaloria occur within a blended learning in-person workshop setting that also includes online communication and project management, as well as interactions with expert mentors including Globaloria staff.

5.2.3 *Six Contemporary Learning Abilities Framework*

The learning objectives and outcomes underscoring the instructional design of the game design program have been described in early phases of the Globaloria project as "6 contemporary learning abilities" or "6-CLAs" (Reynolds and Harel Caperton 2009; Harel Caperton 2010). These dimensions were derived from a theoretical consideration of the skills that are necessary for learners to engage effectively and productively as digital citizens in today's twenty-first century knowledge-based work environments and digital online participatory cultures. Reynolds (2016a) discusses these as "contemporary learning *practices,*" identifying ways in which theory has underscored the development of this learning framework for "social constructivist digital literacy" and its instantiation in the Globaloria learning solution. The 6 dimensions of social constructivist digital literacy are outlined in Table 5.1, column 1. In column 2, we present each dimension's alignment with the instructional design affordances that were offered in Globaloria in 2012/2013, to operationalize them. Column 3 presents research operationalizations that might be used to measure student engagement in the instructional activities— in this case, survey items are presented as one example of an engagement measure.

Productive content creation of an artifact is the primary and central driving activity in the CLAs, as reflected in CLAs 1–3. Learners engage in the latter three dimensions of activity (CLAs 4–6), participating in collaborative inquiry, to support the artifact creation: interact and communicate socially both online and face to face (CLA 4); and find and use information resources and existing examples of the given

Table 5.1 "Social Constructivist Digital Literacy" dimensions: six contemporary learning abilities (Reynolds and Harel Caperton 2009)

The six contemporary learning abilities (6-CLAs): Social constructivist digital literacy	Instructional design affordances in globaloria that cultivate the 6-CLAs Circa 2009–2013	Operationalization of measures for evaluating learning Example: Pre/post frequency survey
1. **CREATE** Invention, creation and completion of a digital project stemming from an original idea, which could include a traditional school subject domain	• Brainstorm, develop game and simulation ideas and storylines using Web 2.0 tools • Generate creative ideas for designs to express the subject of the game and user experience • Write an original game narrative and a proposal to explain it • Plan/program/complete a game file representing the original game design, functionality • Create the initial setup for a blog	• "How often do you…" 6-point Likert scale (1 = *never*, 6 = *several times/day*) • Think up an idea for a creative technology project • Think up an idea for an interactive game • Make computer games • Program a computer
2. **MANAGE** Project planning, project management, teamwork (e.g., role-taking, task delegation), problem-solving	• Coordinate and manage the design/creation/programming of game elements • Manage the project's execution by creating/organizing a wiki and by sharing project assets and progress updates • Manage team work by defining and assigning team roles, coordinating/executing tasks • Use problem solve emergent programming issues involving online tutorials	• Make graphics/animations on a computer • Make digital music/video on a computer • Work on digital design project with team members in person • Use online tutorials to help with digital design projects
3: **PUBLISH** Publishing, distribution of self-created digital artifacts to an audience, community of peers	• Creating wiki profile page and project pages • Posting in-progress and completed text/video/photos/audio/programming code/animations/digital designs on wiki pages	• Post digital design projects online

(continued)

Table 5.1 (continued)

The six contemporary learning abilities (6-CLAs): Social constructivist digital literacy	Instructional design affordances in globaloria that cultivate the 6-CLAs Circa 2009–2013	Operationalization of measures for evaluating learning Example: Pre/post frequency survey
4: **SOCIALIZE** Giving and getting feedback about a project through social interaction, participation, exchange	• Collaborating by using social media tools • Posting to wikis, blogs, open source helps forums, instant messaging • Exchanging/sharing feedback and resources by posting information/links/source code questions/answers • Reading and commenting on others' blogs and wiki pages • Presenting final digital projects for others both virtually in game galleries and in person in live game demonstrations	• Exchange messages in email about a game project • Exchange messages in IM/chat about a technology project • Exchange messages on sites like wiki, blog, Facebook about a technology project
5: **RESEARCH** Inquiry, information seeking, agentive use of resources, to support the artifact's topic, message, design, execution	• Searching the Web for answers and help on specific issues related to programming games • Searching for and finding resources on MyGLife.org network, websites and wikis • Searching the Web for new Flash design, animation and programming resources • Searching for information in support of the game's educational subject and storyline	• Use Wikipedia • Search online when a question emerges • Search online when technology help is needed
6: **SURF/PLAY** Surfing, experimentation, and play with existing networked Web applications and tools	• Surfing to MyGLife.org starter kit site and other game sites and playing games online • Keeping track of and bookmarking surfing results that are relevant to projects • Browsing social media sites such as YouTube, Flickr, blogs, Google tools	• Surf online to find new websites • Play internet games, play software games • Play games on a video game console • Play multiplayer games with others on the Internet

artifact type (CLA 5 and 6). The framework's dimensions can be applied in a range of artifact design contexts. Globaloria's choice of game design as the artifact type is one example. This broad framework outlining social constructivist learning dimensions can help organize others' instructional design and research efforts when digital literacy development is the learning objective.

5.2.4 *Study 1: Cultivation of the "CLAs" Among Student Participants in Globaloria: Research Results on Effects*

Using data from the 2012/2013 school year, Reynolds (2016a) investigates ways in which the CLA dimensions are inter-related when offered in the Globaloria instructional design model to cultivate social constructivist digital literacy. Pre- and post-program surveys were administered to measure middle school and high school students' frequency of engagement in the prescribed Globaloria activities across CLAs. Factor analysis findings (2016) indicated that students' pre-program frequency of engagement in instructional activities factored into six distinct and inter-dependent constructs, in line with the framework above. Results also revealed that, prior to participation, students had lower levels of previous experience in more effortful digital creative activities (e.g., design and creation of project files in software, CLAs 1–3), but higher levels of experience in their uses of online web services for the purposes of surfing, searching and socializing—CLAs 4–6. The opportunity to engage in more creative technology activities (CLAs 1–3) was therefore novel.

Further, results from 2012/2013 demonstrated that students increased in their frequency of engagement across all 6 dimensions from pre- to post-program, both at home and school, even without the assigning of homework. They also showed gains in some categories of motivation and self-efficacy. The magnitude of change appeared larger in the more effortful digital creation categories of CLAs 1–3. These results are notable given that these activities require substantial effort, and in that engagement in productive digital content creation like this has been linked to greater enhancement of one's cultural capital, social mobility, and life and livelihood opportunities in everyday technology use outside of the prescriptive educational intervention context (e.g., Hargittai 2010), suggesting that such benefits may extend to those who learn these practices.

Finally, the research found that student engagement in several activities at-school contributed to their at-home engagement (2016). For instance, a change from pre- to post-program in students' Creating (CLA 1), Socializing (CLA 4) and Surfing (CLA 6) activity at school contributed to a change in their Creating (CLA 1) activity at home, even though they were assigned no homework. These results indicate a transfer of school practices in Globaloria to the home environment for these more challenging creative technology pursuits (at least in the short term) (Reynolds 2016a, b).

5.2.5 Summary of Other Globaloria "Effects" Type Research

Some of the other effects-type research conducted on Globaloria to-date is summarized in Table 5.2 below. The research questions investigated have included:

- Effects of students' participation upon outcome variables such as standardized test scores, game design learning outcomes and career interests;
- Ways in which student participation from pre- to post-program eliminates the known effects of socio-economic status upon digital literacy (in the short term);
- Change in girls' self efficacy toward technology practices, furthering of STEM educational pathways, and career interest development.

The results overall demonstrate evidence of the benefits to students that can be proffered when they have the opportunity to engage in substantive constructionist computing education in the formal school context.

5.2.6 Debates Concerning Structure in Inquiry-Based Learning Contexts

While research evidence such as studies cited in Table 5.2 amply demonstrate a corpus of positive effects resulting from comprehensive learning experiences like Globaloria, debates still arise in the learning sciences literature around the efficacy of these "discovery-based" constructionist approaches. For instance, a widely cited article in the journal *Educational Psychology* by Kirschner et al. (2006) strongly critiques discovery-based approaches as ineffectual, due to a lack of structure in autonomy-supportive inquiry-based learning contexts, and excessive cognitive load that can result, which can over-tax the working memory needed to learn the core material (e.g., introductory computer programming in the case of Globaloria) (2006). These authors (2006) suggest that the emphasis on self-guided learning across time and the extra task of seeking out informational resources can lead to frustration and de-motivation in students, impeding learning progress rather than accelerating it. Therefore, the article recommends close expert-led instruction using highly structured sequences of problem sets that take into account cognitive processes on short-term working memory being investigated in experimental research.

Kirschner et al. (2006) article prompted direct full-article reactions in the literature, in which authors such as Hmelo-Silver et al. (2007) counter-argue that discovery-based interventions involving inquiry are not entirely unguided, but in fact reflect varying extents of structure. These authors (2007) point out that even in learner-centered interventions, student work is structured by systems and/or expert guides and may be better described as "guided" discovery. Scaffolds and instructional contexts supporting inquiry-based learning can and should be designed and specified in the literature to minimize cognitive load effects. A benefit of

Table 5.2 Research on Globaloria to-date

Research question, broadly	Citations	Methods	Results
Effects of intervention on standardized test scores	Chadwick and Gore (2010)	Match-case quasi-experimental research with control groups	Participants in Globaloria performed significantly better in the 2009 WESTEST2 science and social studies subtests than those who did not join the program
	Chadwick and Gore (2011)	Match-case quasi-experimental research with propensity score matching	Students who took part in the Globaloria program scored slightly higher than comparison students on all four sub-sections of the 2010 WESTEST2; however, a significant difference was found only in the WESTEST2 science domain after controlling for previous achievement. This finding suggested that Globaloria participation was positively related to student science performance, but was not related to other subjects tested on the WESTEST2
	Ho et al. (2012)	Match-case quasi-experimental research with control groups	(1) Globaloria participation was positively associated with students' math achievement; (2) Globaloria participation correlated positively with students' reading achievement; (3) There was a significant correlation between Globaloria participation and student science outcomes within the schools struggling with math proficiency; and (4) Globaloria participation was not associated with students' social studies achievement
	Ho et al. (2013)	Match-case quasi-experimental research with control groups	(1) For math, Globaloria participation had a positive effect on high school students who were in schools struggling with low math proficiency. (2) For science, Globaloria participation had a positive effect on high school students who came from low-income families (i.e. students receiving free or reduced-price meals). (3) For social studies, Globaloria participation had a positive effect on boys in middle school

(continued)

Table 5.2 (continued)

Research question, broadly	Citations	Methods	Results
Effect of program participation on reducing known digital divide effects such as gender, SES, and race/ethnicity	Reynolds and Chiu (2015)	Multi-level analysis modeling	(1) Program participation eliminates gender, and, parent education level as a predictor of students' extent of home computer engagement after participating. (2) Students from schools with lower parent education show greater increases in school technology engagement than students from schools with higher parent education, indicating that programs such as this one may be particularly effective in lower socio-economic status communities. (3) Program participation removes prior school achievement as a predictor of students' engagement in advanced computing activities
Effects of at-school versus after school program implementation on student game design learning outcomes	Reynolds and Chiu (2013)	Multi-level analysis modeling	Whether Globaloria was offered as an in-school vs. after-school implementation did not substantially influence the types of changes in student dispositions that the program cultivates, from pre- to post-program. However, implementation context (in-school vs. after-school) did appear to influence learning outcomes such that in-school students appeared to gain more knowledge. Positive changes in intrinsic motivation were found to be associated with change in frequency of engagement in almost all dimensions. Several at-home engagement changes were measured. The lower the parent education among students, the greater the positive changes in self-efficacy for online research

(continued)

Table 5.2 (continued)

Research question, broadly	Citations	Methods	Results
Effects of program participation on girls' identification with STEM fields and careers	Minnigerode and Reynolds (2013), Ashcraft and Reynolds (2014), Ashcraft et al. (2014)	Case study; non-experimental pre/post design	Girls' participation in Globaloria appeared to elicit greater identification with computing, through the affordance of creating games around themes of personal interest and a chance to experience success. Girls' participation offered role-taking experiences in teams that, over time, brought about previously unavailable team leadership opportunities for some. Girls' participation led to increases in their perception that earning a degree in computer science would bring them jobs their family could be proud of

inquiry-based learning is its focus on student-centered inquiry to meet individualized and varying student needs at their level. These personalized approaches contrast with more highly structured, short-term and single-timeframe cognitive approaches to problem set design, which presume that learners share common cognitive processes that can be met with a single, highly structured instructional context that is uniform across all learners (Hmelo-Silver et al. 2007).

Moreover, in further support of inquiry-based approaches, there is a growing research evidence base asserting that students do not necessarily need to be successful in a given learning activity proximally in the short term, to gain an advantage distally. The research on the "productive failure" phenomenon presents evidence that less-structured problem contexts can lead to more long-standing positive learning outcomes because such contexts lead people to understand the deep structure of problems, not simply their correct solutions (e.g., Kapur 2006, 2008; Kapur and Kinzer 2009). Other research studies show that a learner's level of prior expertise in the core knowledge domain as well as in the accompanying inquiry processes, i.e., their status as novices versus experts, is also a salient factor to consider when designing instructional support (National Research Council 2000). Contrasting perspectives like these must continue to be addressed and probed, as we advance the inquiry-based learning agenda in theory and practice.

5.2.7 *Investigating Inquiry and Discovery Processes in Globaloria*

Given these contrasts in the literature, Reynolds and her colleagues continued their investigation into the nuances of student inquiry practices in Globaloria, and their relationship to questions of motivation, autonomy and structure. For instance, Reynolds and Harel Caperton (2011) looked at students' self-reports of what they liked, disliked and found challenging about the inquiry- and autonomy-supportive features of the program context in the 2010 school year. Student responses varied considerably across the questions, in that some students felt that autonomy-supportive features such as using wiki resources to solve design problems were particularly enjoyable, whereas others disliked resource uses and reported that the activity was quite challenging and frustrating. In some cases, within a single individual's response about the wiki resources, evidence of both enjoyment and difficulty/frustration was noted. The results appeared to offer both reinforcing and contradicting evidence for Kirschner et al.'s (2006) critiques of guided discovery due to cognitive load.

Intrinsic motivation. Given these contrasts in student attitudes towards discovery-based learning, Reynolds (2011b) and Reynolds and Chiu (2012) considered student individual motivational differences as factors, through the lens of self-determination theory (SDT) (e.g., Ryan and Deci 2000). These studies (2011b, 2012) explored middle school and high school students' intrinsic and extrinsic

motivational orientations as contributors to outcomes, utilizing both survey data and evaluation measures of the quality of students' creative artifacts as outcome scores. The studies examined whether individual differences in motivational orientation could predict learning outcomes, thus possibly explaining in part the different experiences of students recorded in Reynolds and Caperton (2011). Using a reliable content analysis measurement instrument to elicit a dependent variable for game quality (a proxy for student knowledge) (described in Reynolds 2011a), results illustrated that intrinsic motivation as measured by validated instruments in a pre-survey was, in fact, positively correlated with game quality outcomes, as hypothesized (2011b, 2012). The latter study (2012) employed an advanced statistical multi-level analysis model and additional variables including teacher surveys and student process data such as number of LMS page edits and file uploads, discovering that the following factors contributed to knowledge outcomes: teacher time on task, intrinsic motivational orientation of student teams, and student process actions like wiki edits and uploads. The 2012 study findings suggest that individual differences in motivational disposition may affect the ways in which students experience guided discovery-based game learning in contexts such as Globaloria, which are high in autonomy support. Those with greater extents of intrinsic motivation perform better. These results have implications for ways in which the program can be designed to further scaffold and support a fuller diversity of students. The results also qualify Kirschner et al.'s (2006) critique of discovery-based learning—showing that some students may thrive while others may find autonomy-supportive contexts more difficult. Individual differences play a role in their experiences.

Inquiry processes within guided discovery contexts: What strategies work? The research on motivation discussed in this chapter points to some ways in which individual differences may be factors in students' experiences. However, more understanding is needed regarding the mechanisms by which some students succeed and others may struggle when they engage in the inquiry process during creative projects like game design. We need to better understand what particular activities and affordances are helpful, or not.

Thus, Reynolds et al. (2013) drew upon interview and focus group data with 18 general education middle school students from low-income communities in the U.S. states of Texas and West Virginia about their experiences participating in Globaloria in 2012/2013. The study found that students report using a range of resources including informational wiki resources, human resources such as peers in teams and outside team classmates, books, and even movies to inspire and inform their game design. Two main categories of resource use were identified during that timeframe: (1) toward the game topic and narrative and (2) toward problem-solving game programming issues. Findings reflected that when problem-solving computer programming was set as the task, (a) students developed their own strategies for self- and peer-evaluation and appraisal of their own and others' expertise; (b) they built on these appraisals of peer expertise to self-organize role-taking and task delegation in their teamwork; (c) student leaders at the class level emerged in certain areas of expertise, and they would occasionally displace the teacher as a

knowledge source; (d) some student teams thrived in inquiry while others described being halted and frustrated by the self-organizing approach to problem-solving their programming issues; (e) those who came to a halt discussed wishing for more structure and guidance, from their educator for instance, to keep them back on track. Results also showed that the capacity of the wikis and information resources to support distributed cognition was under-utilized in this school year, suggesting perhaps that students required greater information literacy expertise. The program continues to build its instructional supports and refine the curriculum given such results.

Ongoing qualitative analysis studies of Globaloria (e.g., Reynolds 2014, 2016b) have also employed Google Analytics site metrics data and video observational footage to further investigate student processes during guided discovery. The results from both Google Analytics and video observations studies reveal variation in individual, team and class-level information uses. The results also illustrate relationships between informational resource uses and learning outcomes (game quality). Broadly, the findings relate in a similar way to Kuhlthau et al. (2007) propositions that students' information uses across time yield meaning making and knowledge-building, but results also suggest that in such contexts, students appear to need more direct instruction around information literacy skills (circa 2012/2013). Further, it appears students could benefit from clearer direct teamwork strategies for optimizing their collaboration practices in team-based activities.

In sum, constructionist guided discovery-based game design learning interventions that incorporate autonomy-supportive inquiry activities should scaffold direct instruction deliberately for information seeking skills and teamwork, in addition to lessons supporting the core activity of computer programming. Generally speaking, teachers who wish to leverage the opportunities inherent to inquiry-based approaches need to also consider issues of structure. Further research is recommended on ways in which learners' individual differences, team level factors, class management and pedagogy by the teacher, and instructional design features of the technology and information systems being utilized, may inter-operate in guided discovery.

5.3 Conclusion

Ultimately, the authors of this book aim to help instructional designers and practitioners initiate and leverage students' existing autonomous capacities for "resourcefulness" in the inquiry-based learning interventions we present. We also aim for our interventions to cultivate, strengthen and enrich greater dispositions for such autonomous flow engagement in students. Research evidence indicates that constructionist blended project-based learning opportunities like Globaloria can lead to improved school achievement, new career interests in the STEM disciplines, new dispositions for twenty first century learning across the 6-CLAs, and even mitigation of socio-demographic determinants in the digital divide. There are still

questions to be addressed as we continue to optimize the extent and types of structure afforded by such autonomy-supportive contexts, to benefit a broad range of students with varying motivational capacities and individual differences. More research on student inquiry processes during such learning is recommended to draw out greater nuances of these dynamics.

Existing resources for structuring online information literacies. Instructional resources and lesson plans for information literacy skills abound and can be found through simple online web searches using terms such as "information skills lesson plans". One example of such a resource is the Syracuse University Center for Digital Literacy's information skill lesson plan database "S.O.S. for Information Literacy." Kent State's TRAILS initiative also features lesson plans as well as diagnostic instruments for measuring and assessing students' information skills. School librarians are uniquely suited to help support in this role.

As an extension to the discussion, Leu and his colleagues at the University of Connecticut have set up a "New Literacies" research team, and through their work, offer a set of instructional strategies called "internet reciprocal teaching" (e.g., 2010) based on Palincsar and Brown's (1984) reciprocal teaching model (non-Internet). In both Palincsar and Brown (1984) and Malloy et al. (2010) studies, students gathered in a group of $\sim$4, read a shared text silently (which would be an online text for Leu), then sat together, analyzed and discussed the textual material from various perspectives and roles, including Summarizer, Questioner, Clarifier, and Predictor. They continued around the circle trading and practicing all roles. By learning, adopting, and repetitively practicing these roles, the students were found to appropriate a critical stance to the text and consolidate their metacognitive approaches to reading material in a lasting way. The research on the non-Internet version of reciprocal teaching was meta-analyzed to present a strong evidence base of positive effects in cultivating reading metacognitive strategies in late elementary schoolers (Rosenshine and Meister 1994; Galloway 2003). Leu and his team adapted the approach to the online context with some variations in the role-taking, and confirmed that their approach was also effective for comprehension of online texts.

In this chapter, we have highlighted a dynamic, comprehensive and coordinated approach for teaching social constructivist digital literacy and computational thinking skills through game design and introductory programming. Game design gives students a context for learning using information skills and resources to solve real-world design and programming challenges. Rather than teaching one-off disparate information skills removed from any practical context, the framework for social constructivist digital literacy in Table 5.1 offers a way to ignite students' collective teamwork efforts, and resourcefulness, to create a concrete digital artifact of their very own—one that they can share and be proud of. Autonomous guided inquiry and blended learning contexts will go on proliferating in K-12 education. Resourcefulness is a worthy learning objective for benefiting students in today's instruction, but information skills do not come naturally as the case evidence demonstrates. Approaches such as Leu's, drawing on strengths of research-driven teaching strategies for online reading comprehension, are thereby noteworthy.

Data cited herein also indicates that opening up in-school, formal opportunities like Globaloria for students' inquiry-project-based learning more widely can mitigate known digital divides. With the rapid growth of varied innovative educational computing technologies, Collins and Halverson (2009) propose that informal (for-profit) contexts for learning out of school will begin to eclipse the formal as central loci for teaching and learning in the coming decades. These authors highlight several serious implications for the socio-economically disadvantaged, given what may become a boom in commercialization of digital and e-learning services. The authors advocate public school-based solutions, but state that they are not entirely optimistic that schools can transcend their technology integration challenges. For the sake of equity, educators are encouraged to consider experimenting with new educational technology innovations such as those we outline herein. A pioneering spirit among public educators in initiating their own professional development in this regard may be the key to offering today's and tomorrow's students the chance to cultivate the digital and information skills that will place them on more equal footing as they move into their college years, as those who may enjoy greater privilege of informal learning.

References

American Association of School Librarians. (2007). *Standards for the 21st-century learner*. Retrieved from http://www.ala.org/ala/mgrps/divs/aasl/guidelinesandstandards/learningstandards/standards.cfm

Ashcraft, C., & Reynolds, R. (2014). Girls' identification with STEM through computational media production: Globaloria cases.? In *Paper Presented at the 2014 Digital Media & Learning Conference*, March 2014, Boston, PA.

Ashcraft, C. Wu, Z., DuBow, W., & Reynolds, R. (2014). Assessing girls' interest, confidence, and participation in computing: Lessons from a national socially relevant game design program. In *Paper Presented at the 2014 American Education Research Association (AERA) Conference*, April 2014, Philadelphia, PA.

Barron, B., & Darling-Hammond, L. (2008). Teaching for meaningful learning: A review of research on inquiry-based and cooperative learning. Retrieved from http://www.edutopia.org/pdfs/edutopia-teaching-for-meaningful-learning.pdf

Chadwick, K., & Gore, J. (2010). *Globaloria pilot study: The relationship of Globaloria Participation and student achievement*. Charleston, WV: Edvantia.

Chadwick, K., & Gore, J. (2011). *Globaloria replication study: Examining the robustness of relationships between Globaloria participation and student achievement*. Charleston, WV: Edvantia.

Collins, A., & Halverson, R. (2009). *Rethinking education in the age of technology: The digital revolution and schooling in America*. New York: Teachers CollegePress.

Crook, C. (1997). Making hypertext lecture notes more interactive: undergraduate reactions. *Journal ofComputer Assisted Learning*, *13*(4), 236–244.

Disessa, A., & Cobb, P. (2004). Ontological innovation and the role of theory in design experiments. *Journal of the Learning Sciences, 13*(1), 77–103.

EdWeek. (2011). Technology in Education. Article retrieved July 1, 2014 from http://www.edweek.org/ew/issues/technology-in-education/

Fisher, T., Denning, T., Higgins, C., & Loveless, A. (2012). Teachers' knowing how to use technology: Exploring a conceptual framework for purposeful learning activity. *Curriculum Journal, 23*(3), 307–325.

Galloway, J. P. (2003). *Electronic computing in the electronic age—An electronic textbook*. Merrillville, IN: TMAEducational Services, Media Publishers.

Gulamhussein, A. (2013). *Teaching the teachers: Effective professional development in an era of high-stakes accountability*. A report of the Center for Public Education. Retrieved from http://www.centerforpubliceducation.org/Main-Menu/Staffingstudents/Teaching-the-Teachers-Effective-Professional-Development-in-an-Era-of-High-Stakes-Accountability/Teaching-the-Teachers-Full-Report.pdf

Harel, I. (1991). *Children designers: Interdisciplinary constructions for learning and knowing mathematics in a computer-rich school*. Norwood, NJ: Ablex.

Harel Caperton, I. (2010). Toward a theory of game-media literacy: Playing and building as reading and writing. *International Journal of Gaming and Computer-Mediated Simulations, 2*(1), 1–16.

Harel, I., & Papert, S. (1990). Software design as a learning environment. *Interactive Learning Environments, 1*(1), 1–32.

Hargittai, E. (2010). Digital na(t)ives? Variation in internet skills and uses among members of the net generation. *Sociological Inquiry, 80*(1), 92–113.

Hargittai, E., & Hinnant, A. (2008). Digital inequality: Differences in young adults' use of the Internet. *Communication Research, 35*(5), 602–621.

Hennessey, S., & Deaney, R. (2004). Sustainability and evolution of ICT-supported classroom. Final Report forBecta. Coventry: Becta.

Hmelo-Silver, C.E., Duncan, R.G., & Chinn, C.A. (2007). Scaffolding and achievement in problem-based andinquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist, 42*, 99–107.

Ho, H., Gore, J., & Chadwick, K. (2012). *Globaloria replication study: An examination of the relationships between Globaloria participation and student achievement in Year 4 of the West Virginia pilot implementation Charleston*. WV: Edvantia Inc.

Ho, H., Gore, J., & Chadwick, K. (2012). *Globaloria replication study: An examination of the relationships between Globaloria participation and student achievement in Year 4 of the West Virginia pilot implementation Charleston*. WV: Edvantia Inc.

Hobbs, R. (2010). *Digital and media literacy: A plan of action*. White paper issued by the Aspen Institute.

Horrigan, J. B. (2011). What are the consequences of being disconnected in a broadband-connected world? *Daedalus, 140*(4), 17–31.

International Society for Technology in Education. (2007). NETS for students 2007. Retrieved from http://www.iste.org/standards/nets-for-students.aspx

International Society for Technology in Education. (2008). NETS for teachers 2008. Retrieved from http://www.iste.org/standards/nets-for-teachers.aspx

Jenkins, H. (2009). *Confronting the challenges of participatory culture: Media education for the 21st century*. Cambridge, MA: The MIT Press.

Kafai, Y. B. (1995). *Minds in play: Computer game design as a context for children's learning* (p. 1995). Mahwah, NJ: Lawrence Erlbaum.

Kafai, Y. B., & Resnick, M. (Eds.). (1996). *Constructionism in practice: Designing, thinking, and learning in a digital world*. Mawhaw, NJ: Lawrence Erlbaum Associates.

Kapur, M. (2006). Productive failure. In *Paper presented at the International Conference on Learning Science*, Bloomington, Indianna.

Kapur, M. (2008). Productive failure. *Cognition and Instruction, 26*(3), 379–424.

Kapur, M., & Kinzer, C. K. (2009). Productive failure in CSCL groups. *International Journal of Computer-Supported Collaborative Learning, 4*(1), 21–46.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry based teaching. *Educational Psychologist, 41*(2), 75–86.

Knight Commission. (2009). Informing communities: Sustaining democracy in the digital age. Retrieved from www.knightcomm.org/wpcontent/uploads/2010/02/Informing_Communities_Sustaining_Democracy_in_the_Digital_Age.pdf

Kuhlthau, C., Maniotes, L., & Caspari, A. (2007). *Guided Inquiry: Learning in the twenty-first century*. Westport, CT: Libraries Unlimited.

Lacey, T. A., & Wright, B. (2009). Occupational employment projections to 2018. *Monthly Labor Review, 132*(11), 82–123.

Law, N., Pelgrum, W. J., & Plomp, T. (Eds.). (2008). *Pedagogical practices and ICT use around the world: Findings from an international comparative study*. Dordrecht: Springer, Comparative Education Research Centre, The University of Hong Kong.

Livingstone, S., Van Couvering, E., & Thumim, N. (2005) Adult media literacy: A review of the research literature. Retrieved from http://stakeholders.ofcom.org.uk/binaries/research/media-literacy/aml.pdf

Malloy, J. A., Castek, J. M., & Leu, D. J. (2010). Silent reading and online reading comprehension. *Revisiting silent reading: New directions for teachers and researchers*, 221–240.

Marshall, G., & Cox, M. J. (2008). Chapter 2: research methods; their design, applicability and reliability. In J. Voogt & G. Knezek (Eds.), *international handbook of information technology in primary and secondary education* (pp. 983–1002). Berlin, Heidelberg, New York: Springer.

Meyer, E. J., Abrami, P. C., Wade, A., & Scherzer, R. (2011). Electronic portfolios in the classroom: Factors impacting teachers' integration of new technologies and new pedagogies. *Technology, Pedagogy and Education, 20*(2), 191–207.

Minnigerode, L., & Reynolds, R. (2013). Don't give up: A case study on girls and video game design. *Learning Landscapes*, *6*(2).

Mossberger, K., Tolbert, C. J., & McNeal, R. S. (2007). *Digital citizenship: The internet, society, and participation*. Cambridge, MA: MIT Press.

Mumtaz, S. (2001). Children's enjoyment and perception of computer use in the home and the school. *Computers & Education, 36*, 347–362.

National Research Council. (2000). *How people learn: Brain, mind, experience, and school* (Expanded ed.). Washington, DC: The National Academies Press.

Norris, C. & Soloway, E. (2011, November/December). The 10 barriers to technology adoption. District Administration.

Organisation for Economic Co-operation and Development (OECD). (2006). Glossary of statistical terms: Digital divide definition. Retrieved Dec 14, 2015 from https://stats.oecd.org/glossary/detail.asp?ID=4719

Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction, 1*(2), 117–175.

Papert, S., & Harel, I. (Eds.). (1991). *Constructionism*. Norwood, NJ: Ablex Publishing.

Passey, D. (2006). Technology enhancing learning: Analysing uses of information and communication technologies by primary and secondary school pupils with learning frameworks. *Curriculum Journal, 17*(2), 139–166.

Passey, D., Rogers, C., Machell, J., McHugh, G., & Allaway, D. (2003). *The motivational effect of ICT on pupils*. Annesley: DfES.

Pew Internet and American Life Project. (2007). Teens and social media. Retrieved from http://www.pewinternet.org/Reports/2007/Teens-and-Social-Media.aspx

Reynolds, R. (2011a). Possible contributors to evaluated student outcomes in a discovery-based program of game design learning. In *Paper presented at the annual convention of the American Education Research Association (AERA)*, April 2011, New Orleans, LA.

Reynolds, R. (2011b). Children's game design learning in discovery-based contexts: Contribution of intrinsic and extrinsic motivational orientations to student outcomes. In *Paper presented at the annual International Communication Association (ICA) conference*, May 2011, Boston, MA.

Reynolds, R. (2014). Learning management system trace logs and Google Analytics page reads as data sources for evaluating student inquiry and collaboration practices during game design

learning. In *Proceedings of the 2014 International Conference of the Learning Sciences* (ICLS) conference, Boulder, CO.

Reynolds, R. (2016a). Defining, designing for, and measuring "Digital Literacy" development in learners: A proposed framework. *Educational Technology Research & Development*. Accepted for publication, early 2016.

Reynolds, R. (2016b). Relationships among tasks, collaborative inquiry processes, inquiry resolutions, and knowledge outcomes in adolescents during guided discovery-based game design in school. *Journal of Information Science, 42*, 35–58.

Reynolds, R., & Chiu, M. (2012). Contribution of motivational orientations to student outcomes in a discoverybasedprogram of game design learning. *Proceedings of the International Conference of the Learning Sciences (ICLS)*, July 2012, Sydney, Australia.

Reynolds, R., & Chiu, M. (2013). Context matters: The effect of formal and informal context differences upon pre- to post-program changes in student engagement in a program of game design learning. *Journal of Learning, Media & Technology*. April 2013. http://dx.doi.org/10.1080/17439884.2013.779585

Reynolds, R. & Chiu, M. (2015). Reducing digital divide effects through student engagement in coordinated game design, online resource uses, and social computing activities in school. Accepted to the *Journal of the Association for Information Science and Technology* (JASIST).

Reynolds, R & Harel Caperton, I. (2009). Development of high school and community college students' contemporary learning abilities in a game design program. In *Paper Presented at the annual conference of the American Educational Research Association*, April 2009, San Diego, CA.

Reynolds, R., & Harel Caperton, I. (2011). Contrasts in student engagement, meaning-making, dislikes, and challenges in a discovery-based program of game design learning. *Educational Technology Research and Development, 59*(2), 267–289.

Reynolds, R., Hmelo-Silver, C., Sorenson, L., & Van Ness, C. (2013). Interview findings on middle schoolers' collaboration in self-organizing game design teams. In *Proceedings of the 2013 International Conference of Computer-Supported Collaborative Learning*, July 2013, Madison, WI.

Rodríguez, P., Nussbaum, M., López, X., & Sepúlveda, M. (2010). A monitoring and evaluation scheme for an ICT-supported education program in schools. *Educational Technology & Society, 13*(2), 166–179.

Rosenshine, B., & Meister, C. (1994). Reciprocal teaching: A review of the research. *Review of EducationalResearch, 64*(4), 479–530.

Ryan, R. M., & Deci, E. L. (2000) Self-determination theory and the facilitation of intrinsic motivation, socialdevelopment, and well-being. *American Psychologist*, *55*, 68–78.

Sawyer, R. K. (Ed.). (2005). *The Cambridge handbook of the learning sciences*. Cambridge: Cambridge University Press.

Stager, G. (2001). *Computationally-rich constructionism and at-risk learners*. Retrieved from http://www.stager.org/wcce/index.html

The National Broadband Plan. (2010). *Broadband.gov*. Retrieved April 24, 2014 from http://www.broadband.gov/plan

U.S. Department of Education. (2010, November). *National education technology plan*. Retrieved from http://www.ed.gov/sites/default/files/netp2010-execsumm.pdf

Voogt, J., & Knezek, G. (2008). *International handbook of information technology in primary and secondary education*. Berlin, Heidelberg, New York: Springer.

Vygotsky, L. S. (1962). *Thought and language*. Cambridge, MA: The MIT Press.

Watters, A. (2015, Feb 2). Who's Investing in Ed-Tech? HackEducation. Retrieved December 14, 2015 from http://hackeducation.com/2015/02/05/whos-investing-in-ed-tech/

Wellings, J., & Levine, M. (2009). *The digital promise: Transforming learning with innovative uses of technology*. New York: Joan Ganz Cooney Center at Sesame Workshop.

Yeh, C. C., Chang, D. F., & Chang, L. Y. (2011). Information technology integrated into classroom teaching and its effects. *US-China Education Review, B6*(2011), 778–785.

Yoon, K. S., Duncan, T., Lee, S. W. Y, Scarloss, B., & Shapley, K. L. (2007). Reviewing the evidence on how teacher professional development affects student achievement. *Issues and answers report* (REL 2007-No. 033). Washington, D.C.: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southwes. http://ies.ed.gov/ncee/edlabs

Part III
Twenty-First Century Skills Education in Schools

Chapter 6
Teachers' Professional Development

In the previous chapters, we have identified the sets of twenty-first century skills that are essential to learners' education, and discussed how their development of such skills can be scaffolded by applying various strategies, using examples from Hong Kong, Switzerland, and the United States. This chapter marks the beginning of the third section of the book and takes readers' understanding of teaching twenty-first century skills further beyond theory. It aims to guide education professionals along the process of actualizing twenty-first century skills education in three steps, starting with the teacher's own acquisition of relevant skills as discussed in this chapter, followed by development of learners' twenty-first century skills using suitable pedagogy advocated in Chap. 7, and finally the assessment of learner performance for evaluation and improvement in Chap. 8. This chapter focuses on the first step toward achieving this goal—to equip teachers, mainly those currently in service, with the ability to accomplish the mission of developing students' twenty-first century skills.

The world has seen rapid changes in the demand for talents in nurturing future leaders, and fueling the necessary workforce is a major concern in the educational field. The professional development of teachers to enhance teachers' knowledge and skills, has thus become a top priority. In order to effectively foster students' development of twenty-first century skills, teachers themselves must have a good command of these skills, and be well prepared in their own capacity to impart such skills onto students. A quick search in the existing literature yields a less than satisfactory result for professional development specifically designed for twenty-first century skills teaching, especially for in-service teachers. This is a grave issue as teachers educated and trained under the old teaching model in past decades are neither adequately aware of nor ready with all the skills to create a twenty-first century teaching environment for their students' learning. The exact areas they are weak in have not received sufficient attention in the literature either. With the aims to provide stronger educational support to in-service teachers in their adoption and development of new skills in twenty-first century teaching, this chapter first highlights the skills and capacities that teachers lack, then suggests

S.K.W. Chu et al., *21st Century Skills Development Through Inquiry-Based Learning*, DOI 10.1007/978-981-10-2481-8_6

methods for teachers' reference in their acquisition or strengthening of such skills to keep themselves in line with contemporary educational development.

6.1 Skills Needed for a New Teaching Style

Well-rounded student development no longer refers only to intellectual growth, but involves the mastery of various skills such as critical thinking, problem solving, communication and collaboration skills (Partnership for twenty-first Century Skills 2009), as we have discussed in Chap. 2. In response to such a change, teachers need to meet new expectations to facilitate the development of twenty-first century skills in student-centered learning, with one prime example being the ISTE standard for teachers (International Society for Technology in Education 2008).

Getting teachers prepared for the launch of a new twenty-first century skills oriented teaching style is no easy task. It is proposed that most of the learning goals of twenty-first century skills can be taught within the context of scientific inquiry or project-based learning (Windschitl 2009) which requires teachers to be able to engage students in self-directed strategies, to organize activities that delegate learning decisions to students and monitor their progress, to facilitate learning activities such as collective problem solving, and to guide students in thinking about complex problems by giving them feedback following assessment (Rapporteur 2010). In easing the "ambiguity" (Windschitl 2009) of such a novel teaching model, this section aims to explore areas that teachers need to polish their own skills in so as to effectively support the teaching of and help students develop twenty-first century skills, namely teachers' attitudes toward and competencies of adopting twenty-first century skills, their pedagogical orientation and professional identity.

6.2 Teachers' Adoption of Twenty-First Century Skills

Those who pay attention to teacher education over the years may have noticed a paradigm shift from a knowledge-oriented curriculum to one that stresses more the activities and practices that bring about knowledge acquisition (Zeichner 2012; McDonald et al. 2013). However, a considerable proportion of in-service teachers may have been trained in more conventional ways. They may have limited exposure to various practice-based learning approaches such as inquiry learning—the cradle for twenty-first century skills development. Successful teacher adoption of twenty-first century skills, for both their personal use and passing on to students, hinges on their attitude toward, awareness of and willingness to learn and use them. It also depends on their ease of utilizing such skills. Our discussion below shows that, among the components of twenty-first century skills, many teachers are

particularly lacking in information technology literacy, information literacy, media literacy as well as digital collaboration skills. These limitations may affect their teaching performance in leading, guiding, modeling for and probing students in evidential explanation to help them acquire twenty-first century skills in a student-centered and inquiry-based learning mode.

6.2.1 *Information Technology Literacy*

Information technology (IT) literacy is the most fundamental among the set of digital literacies. IT literacy is the first skill teachers must acquire in order to master all the three skills under the umbrella of digital literacy, as the search for and organization of information is largely supported by technology nowadays, as well as the creation and utilization of media (Barone 2012; Safar and AlKhezzi 2013). There is an increasing trend for technology integration in the classroom, requiring teachers to incorporate technology into their pedagogy (Kopcha 2012; Richards 2006; Wilson and Christie 2010). In particular, the Technological Pedagogical Content Knowledge (TPACK) model put forward by Koehler and Mishra (2009) as a framework to aid teachers in their quest to integrate technology into their teaching is becoming widely adopted in the professional development of teachers (Archambault and Crippen 2009; Harris and Hofer 2011; Schmidt et al. 2009).

Teachers progress through various stages of technology adoption, beginning with being alert to the possibilities of technology implementation for both personal purposes and letting students acquire IT literacy in their everyday learning. This awareness eventually brings about routine utilization of technology, and with appropriate training and support, they advance to more creative usage of technology for teaching and learning (Christensen and Knezek 2008; Sandholtz et al. 1997). On the bright side, recent research has reported teachers' competence and confidence in providing instruction using technology (Ismail et al. 2011; Kopcha 2012). Nevertheless, teachers who have admitted facing barriers to technology integration over the years are commonly found to be lacking in access to hardware and software, training and support, and they often have little trust or belief in technology (Bhalla 2012; Dawson 2008; Ertmer et al. 2012; Kopcha 2012).

Access to hardware and software is noted to be the basic criterion for technology utilization at school. Technology infrastructure available to teachers has to be reliable and useful to serve their purposes. If technology usage is time consuming or perceived not to contribute to students' learning process, teachers will be inclined not to use it (Kopcha 2012). Besides, if hardware or software provided for teaching and learning is insufficient, it is difficult to fulfill the need of facilitating student-centered learning. In reality, compared to the past when teachers had to, for example, ask for computers to be installed directly in classrooms (Clark 2006), technology is now more easily accessible for teaching and learning. A survey conducted in 2010 indicated that over 90 % of computers in U.S. schools are used for instructional purposes, and that the ratio of students to instructional computers with Internet access was 3:1

(Gray et al. 2010). While computers are more handy, the same study revealed that students do not have ready access to mobile computers or devices, and that Internet access in classrooms is not always reliable (Gray et al. 2010).

The definition of access can be extended from beyond the school campus to computer and Internet access at home. It has been evidenced that teachers exhibit a higher level of confidence in their IT skills competency if they have both on-campus and home access to computers (Ismail et al. 2011; Kahveci et al. 2011) and the Internet (Condie and Livingston 2007). The availability of technology infrastructure to teachers also boosts their confidence in using IT professionally, for example, in using word processing softwares, and saving and accessing shared files (Ismail et al. 2011). This brings our discussion to the next point concerning attitudinal issues of teachers towards IT.

Teachers' beliefs in IT and confidence in their own IT skills are two prime attitudinal obstacles toward effective technology integration in their teaching (Bhalla 2012; Kopcha 2012; Ottenbreit-leftwich et al. 2010). Specific concerns that teachers harbor include their worry that the syllabus cannot be completed on time should computers be used in teaching and learning, and their fear that computers may be broken, lost, or damaged during use. These two worries had the highest ranking in the category of attitudinal challenges in the study conducted by Bhalla (2012). Studies in the area have shown that teachers' beliefs on IT are positively linked to their IT practices (Ertmer et al. 2012; Ottenbreit-Leftwich et al. 2012). If teachers feel uncomfortable with the use of technological tools or are apprehensive that they may not be qualified to teach using IT, there are less likely to incorporate technology into their teaching, resulting in less interaction between students and technology.

6.2.2 Information Literacy (IL)

The rise of inquiry project-based learning places teachers in their new role of facilitators, guiding students through the understanding and exploration of chosen topics (Harada and Yoshina 2004). Teachers' capacity to apply research and problem-solving skills are required to facilitate students' development in inquiry-based learning. In the process of equipping themselves with knowledge on the wide variety of topics potentially chosen by students, teachers have to organize abundant information in and integrate different contextual materials into the curriculum. After students have submitted their inquiry learning projects, teachers often have to review and validate resources they cited in student assessments. Precisely, inquiry teaching requires teachers to possess specific knowledge of how to support students in developing researchable questions, planning an investigation, collecting and interpreting data, and presenting results (Gess-Newsome and Lederman 1999).

The issues concerning teachers' IL skills commence with the pivotal question of teachers' understanding of the term IL. In a research study conducted by Probert

(2009), it is found that the two-thirds of New Zealand teachers who participated in the survey demonstrated limited or no understanding of IL, judged by the way they defined an information literate person. These teachers could only give general and vague descriptions that loosely define IL. There was also a misconception that IL skills are the same as ICT skills. This finding is echoed by a similar study involving 500 high school teachers in Greece (Korobili et al. 2011), in which the notion of IL was observed to be poorly understood, and often mixed up with computer literacy. Teachers even falsely conceptualized the computer literacy training they attended as IL training. Little improvement is seen in a more recent study, in which respondents were still unfamiliar with the term (Smith 2013). In Smith's study, respondents gave inconsistent definitions of IL, ranging from something as broad as an all-encompassing set of literacy and relevant information skills to a definition as narrow as the ability to find information.

There are also problems found in teaching information literacy to students. Overall, teachers find it difficult to align the development, delivery, and assessment of IL instruction to their existing curriculum objectives (Williams and Wavell 2007; Smith 2013). Some teachers may have received training on information processing models—models that divide the process of seeking information into manageable stages, starting from identifying questions to locating information sources, as well as the stages of information evaluation and management (Probert 2009). However, these models were rarely used, and in cases where teachers claimed to apply such models in class, they were unfamiliar with the stages of the model, or have mistaken irrelevant techniques as an information processing model (Probert 2009). Some teachers also exhibited a low level of confidence in deciding on teaching topics, the first step of many information processing models (Gawith 1988; Australian School Library Association 2001), as they tend to seek clarification on the finer details of the topic requirements in their initial preparation (Merchant and Hepworth 2002). Although teachers are generally confident in their own ability to retrieve information (Korobili et al. 2011), some of them show little awareness of the need for and benefits of engaging students in the process of information search (Merchant and Hepworth 2002). These teachers view it as their responsibility to research into and prepare materials for their students when learning a new topic important, thereby reducing students' opportunities to practice information access and use. This is problematic as it is the teacher's level of consciousness or awareness of IL skills rather than their own IL level that ultimately determines students' IL competency (Merchant and Hepworth 2002). In the same study, students' experience were also suggestive of improvement needed in teachers, as they reported that they received not much assistance in evaluating the quality and source of information gathered.

6.2.3 Media Literacy (ML)

Media education is most effective when teachers have clear expectations of students' media consumption habits and media awareness to be able to design a

tailor-made media education program for their students' maximum benefit and to evaluate their improvement and that of the program itself (Chu et al. 2010). Since children in the present era are exposed to media content from a much earlier stage at a more frequent rate via the Internet and popular social media such as Facebook (Prensky 2001), teachers may have the wrong assumption that their digital native students are having the same level of media literacy as they do, and that the conventional media education curriculum that worked for the teachers at their school age still fits their students now (Buckingham 2002). This wrong estimation of students' media consumption habits and awareness may either waste students' time of learning something they have already acquired or lead to an inappropriate design and a misapplied and insufficient focus on media education (Chu et al. 2010). Teachers' realistic understanding thus plays an influential role in students' future development and learning outcomes. However, a survey conducted in 2010 to assess and investigate Hong Kong teachers' understanding of and expectation toward their students' media literacy showed that teachers' understanding toward students' media consumption habits deviated from reality and they tended to overestimate students' preference for online game (Chu et al. 2010). As conceived by Burnett (2002), the discrepancy between teacher–student assumptions of media consumption habits reflected in the survey points to the fact that local teachers are short of the skills needed to comprehend the overall picture of their students' media consumption and hence not capable enough to design a media education curriculum with the right resources and assessment methods for them.

Furthermore, ML includes one's skillful use of media tools and sharing of appropriate and relevant information with others (Hobbs 2010). To be competent in ML, teachers not only have to acquire a basic level of understanding in mastering the media tools, but also keep themselves abreast with new technologies and skills required to maintain and promote the quality and capability of accessing information through various media. The purpose of using media in the classroom is often limited to one-way information presentation from the teacher to students (Keengwe and Kang 2013). There is a perceived lack of interaction between students and technology, in which students remain in the receiving end of the media, owing to the predominant use of technology such as PowerPoint and video clips in teachers' presentations. The reason behind students' passive role in media utilization in class is the consequence of teachers' unfamiliarity with the software chosen for students to create PowerPoint presentations, and their lack of skills to facilitate students' use of the media. This recent study shows that teachers' ML proficiency highly influences students' media usage, and hence their ML.

6.2.4 Collaboration Skills

In order to develop and sharpen one's skills of collaborating with peers and becoming a team player, one very effective way is to learn through experience—to collaborate with fellow classmates in activities that encourage social interaction

(Cortez et al. 2009). In the course of collaborative learning, the traditional role of the teacher as the lecturer is replaced by that of a facilitator (Chu et al. 2012). With this change in the teacher's role from a knowledge deliverer to a mediator of students' knowledge development, new tools and pedagogies are needed to appropriately scaffold students' acquisition of collaboration and communication skills.

Various kinds of software and platforms, such as blogs (Kim 2008), forums, (Cook et al. 2014) and wikis (Chu et al. 2012) assist collaboration among teachers, groups of students as well as between the teacher and students. In particular, there is widespread recognition of the collaborative potential of wiki as substantiated by the rapidly growing number of its applications in group work across disciplines and levels of study (Caverly and Ward 2008; Chu 2010). While discussion on IT literacy in Sect. 6.2.1 focuses on the types and frequency of software utilization, this section about collaboration gives emphasis to the purpose for which software is used. It appears that despite the enthusiasm expressed by scholars on wiki-assisted collaborative learning, teachers are yet to catch up with the trend. In a study documenting wiki usage in U.S. K-12 schools (Reich et al. 2012), only a meager 1 % percent of wikis served as a tool for students' collaborative projects. This finding contrasted with the statistics indicating that 21 % of the teachers reported requiring their students to contribute to blogs or wikis (Gray et al. 2010). Juxtaposing this with two other discoveries in Reich et al.'s study that 25 % of wikis were used in individual student assignments which involved minimal collaboration and that 34 % of wikis were merely used for delivery of teaching materials, it seems to be obvious that teachers to date may not have fully comprehended and maximized the potential of wikis in facilitating student collaboration.

After taking the first step to adopt collaborative tools in teaching and learning, it is imperative that teachers take the necessary measures to ensure sufficient and effective communication among students on the chosen collaborative platform. Without the teacher's timely support and mediation, collaboration requires a lot more effort and becomes time consuming, leading to failure in task completion (Rummel and Spada 2005). But as students advance in their collaboration skills, they gradually require less guidance to complete their assigned group work. In order to design collaborative learning activities most suited to students' experience and level, teachers should be able to observe and judge the levels of student ownership of the inquiry mode, as Heick (2013) has termed, and decide on the degree of freedom to be given to students in terms of the research question to be set, study methods, data collection, choice of presentation, and collaboration tools.

To integrate twenty-first century skills into the current teaching content, teachers have to be open to ongoing professional development. It does not suffice for teachers to only focus on routine practice of instruction in their respective classrooms and disregard other teachers. In addition to keeping track of their own professional learning, it is beneficial that teachers share their knowledge with colleagues in a community of practice, engage in reflections of their own teaching, are ready to take risks and foster trust within the community of practice (Law et al.

2008). Scholars have proposed that such a relationship among teachers can be built with the assistance of technology and collaboration with other educators. Riel and Becker (2008) have shown that teachers who adopt a leadership role are more likely to use technology in creative ways than other teachers. Voogt (2010) has found that teachers who work more closely with their counterparts are more professionally engaged than teachers who have a traditional pedagogical orientation. Similarly, Drent and Meelissen (2008) have observed that teachers, who use technology in twenty-first century learning settings, are more likely to enact the educational change that is needed in moving in this teaching direction.

Teachers should mentally prepare themselves for adopting twenty-first century teaching skills prior to actual changes, so as to professionally identify and engage in corresponding teaching roles with the use of technology and collaborative networks. Teachers' willingness to collaborate with one another is also rather heavily influenced by the school culture. It has been shown there is a positive correlation between teacher collaboration with and the support they receive from the school. For cases in which resources, in terms of time and training, are not sufficient for the development of collaborative relationships, teachers are more inclined to center their attention on their individual work and less prepared to increase their workload to reach out and collaborate (Leithwood et al. 2000; Little 2003). Besides, it is essential that teachers and administrators in the school share common goals and values in their work. School principals can foster a school climate that promotes professional learning, by employing strategies such as attending to the school's specific priorities (e.g., financial or structural), cultivating shared values and flexibility among staff members, and building a culture of collaboration (Drago-Severson 2012).

6.3 Acquisition of Twenty-First Century Teaching Skills

After reviewing the components of twenty-first century skills that teachers should possess for their own use and for them to pass on to students, we explore ways of getting teachers to process, understand, and internalize these necessary skills for modern teaching and learning. Section 6.3 recommends tools and resources that teachers may find useful in designing learning activities that facilitate both teachers' and in turn students' acquisition of twenty-first century skills. This section takes one more step forward and suggests that schools adopt professional development strategies to maximize teachers' potential in cultivating students' twenty-first century skills.

6.3.1 Twenty-First Century Skills Standards for Teachers

Teachers may use various frameworks developed for twenty-first century skills education (see Chap. 2) as reference. All standards describe what a twenty-first

century student should be capable of doing, from which teachers can develop teaching strategies that facilitate the learning process. Specifically, the ISTE NETS for teachers puts forward the following abilities required of teachers in order to effectively teach twenty-first century skills:

1. To Facilitate and Inspire Student Learning and Creativity: Teachers use their knowledge of subject matter, teaching and learning, and technology to facilitate experiences that advance student learning, creativity and innovation in both face-to-face and virtual environments.
2. To Design and Develop Digital-Age Learning Experiences and Assessments: Teachers design, develop, and evaluate authentic learning experiences and assessment incorporating contemporary tools as well as resources to maximize content learning in context and to develop the knowledge, skills and attitudes identified in the NETS•S (National Educational Technology Standards for Students).
3. To Model Digital-Age Work and Learning: Teachers exhibit knowledge, skills, and work processes representative of an innovative professional in a global and digital society.
4. To Promote and Model Digital Citizenship and Responsibility: Teachers understand local and global societal issues and responsibilities in an evolving digital culture and exhibit legal and ethical behavior in their professional practices.
5. To Engage in Professional Growth and Leadership: Teachers continuously enrich their professional practice, model lifelong learning, and exhibit leadership in their school and professional community by promoting and demonstrating the effective use of digital tools and resources (ISTE NETS Standards for Teachers 2008).

6.3.2 Strategies to Develop Teachers' Twenty-First Century Skills

After introducing three tools that teachers may use to improve their own twenty-first century skills and those of their students, we come to the section that discusses the strategies through which teachers can develop such skills or to learn how to utilize the above tools.

6.3.2.1 Collaborative Inquiry

The ultimate aim of teacher professional development is to improve teaching practice. In this regard, inquiry learning is often recognized as a way of encouraging shifts in teaching practice in terms of self-improvement and classroom behavior (Bray 2002; Hughes and Ooms 2004). Inquiry-based professional development is

no different from inquiry-based projects undertaken by students: teachers are required to draw on resources from the literature and experience of their own or their colleagues to guide inquiry in a sustained and reflective manner (Butler and Schnellert 2012), and such inquiries are carried out over a period of time (Dede et al. 2008). This feature makes inquiry programs superior to workshops and seminars, as the latter are usually not coherent and lack the depth to provide ongoing support for implementation of new pedagogies (Sandholtz 2002; Hughes and Ooms 2004). In the inquiry, teachers may address common issues of teaching and learning to sustain educational reforms, and then collectively come up with solutions to the concerns identified (Deni and Malakolunthu 2013).

One benefit of teachers' collaborative inquiry efforts is their increased attempts to problem-solve (Deni and Malakolunthu 2013). Through teachers' concerted effort, they engage in conversations that examine the causes and impact of instructional problems, such as classroom dynamics, student and teacher conduct. Teachers' patterns of thinking are progressively oriented toward problem solving, with discussions and diagnostic viewpoints supported by examples and evidence, which lead to new angles and possibilities to solve problems. Having gained first-hand experience in collaborative inquiry, teachers can evaluate their performance and pass on relevant skills and knowledge to their students, as various inquiry cycles have shown (Butler and Schnellert 2012; Nelson and Slavit 2008).

Through identifying the purpose and topic of investigation, teachers in the same inquiry group agree on common initiatives for participation, a key source of motivation that accounts for the success of inquiry programs (Hughes and Ooms 2004). Inquiry programs provide opportunities for teachers to work together with their colleagues, allowing teachers who normally teach individually to interact with others at work and stimulate one another to reflect on their teaching practice (Sandholtz 2002). Empirical evidence has shed light on collaboration of this nature improving working relationships among colleagues (Bray 2002).

Support for teacher inquiry programs is essential to facilitate fruitful professional development. Both the support for the collaborative inquiry process and for an inquiry environment are highly relevant in this case (Nelson and Slavit 2008). The former refers to facilitative processes that create room for teachers to discuss their inquiry path and progress along an inquiry cycle, for example through the adoption of protocols to structure collaborative data analysis. These measures may strengthen teachers' abilities to challenge existing beliefs with a critical eye. The latter involves reinforcement from external stakeholders such as school, district or state initiatives, and established norms of collaboration or experts invited from outside the school. Forming partnerships with universities is one pragmatic way of obtaining such support for teacher development, as discussed in the following section.

6.3.2.2 Partnering with Universities

Schools and universities often join hands in the quest of developing teachers' twenty-first century skills. Collaboration of this type may be organized in different

forms. Smaller scale, subject-specific activities may be more suited to projects with less funding, while this is also possible for a series of professional development events aiming for ongoing critical reflection on challenging contents (Sandholtz 2001). Such kind of collaboration is mutually beneficial. Academic researchers play a leading role in the integration of theory and practice by offering their expertise on theoretical knowledge so that teachers may refine their practical skills (Baumfield and Butterworth 2007). Theoretical knowledge, however, is not exclusive to university academics. In fact, teachers are recognized for their intellectual leadership capacity too and make huge contributions as teacher researchers (Zeichner 2003). With solid frontline experience, teacher researchers have the power to redefine and transform existing understanding on teaching and learning (Baumfield and Butterworth 2007), which is valuable information for the research of university staff.

The target participants of partnership programs between schools and universities are not limited to teachers and university academics. Many activities have a primary purpose beyond teachers' professional development. Notably, students are often included in these partnership studies (Sandholtz 2001). For example, a study on upper primary four students' media awareness (Chu et al. 2010) investigates both teachers' understanding on their students' media literacy, and students' evaluation of their own media awareness. Within the study, teachers took part in an introductory workshop on media education that encouraged incorporation of media use into the curriculum. They were asked at the end of the workshop to predict their students' media awareness and media use patterns by completing a questionnaire. The students filled in the same questionnaire, and the results were compared to the teachers' prediction. Teachers' lack of knowledge of students' media awareness revealed a potential research direction on professional development that targeted at deepening teachers' understanding of students' media literacy. The findings also alerted teachers to the need to pay attention to students' media usage and to design pedagogies that best facilitate students' twenty-first century skills building.

Another example of school-university partnership is the Globaloria Program devised for both students and educators to engage in social and collaborative game design and construction using open source Web 2.0 platforms so as to boost their proficiency in higher order skills and concepts needed for twenty-first century citizens (Whitehouse et al. 2009). A set of 6 contemporary learning abilities for teacher professional development was developed, incorporating twenty-first century skill components including collaboration, creativity, information literacy, information technology literacy, and media literacy. This set of contemporary learning abilities was arrived at based on the researchers' empirical observations, and is useful for further research, as well as application by teachers and students.

6.3.2.3 Formal Training Courses

Formally structured courses are organized, often by higher education institutes, to serve the purpose of enhancing teachers' capacity to adapt to changes required in

twenty-first century teaching. By these courses, we refer not to short, one-off workshops or seminars without follow ups which do not suffice to cast a long-lasting impact on teaching and learning (Hughes and Ooms 2004). We recommend courses that may address various aspects of twenty-first century skills, and that are held over a period of time to allow teachers the time needed to digest what they have learnt. Such courses include university-organized in-service professional development programs for teachers, for example, courses exploring task-based learning making use of portfolio development (Liu 2011) and courses instructing teachers how to integrate the technique of digital storytelling into the classroom (Chung 2006). These courses guide teachers step-by-step through the process of implementing the pedagogy, providing them with the necessary knowledge and skills, as well as chances to share them with colleagues at work.

6.3.2.4 Teacher Communities

Peer support in the form of the teacher communities is another way to engage teachers in the professional development of twenty-first century skills. In teacher communities, teachers with common goals in areas such as teaching and problem solving can exchange ideas on classroom practice and student learning, develop and share teaching materials, observe one another teach when possible, and offer advice that helps members of the community learn new ways of teaching (Lomos et al. 2011; Little 2012). Most professional communities focus on the concept that collaboration among teachers promotes teacher learning, which in turn improves their teaching and student learning (Levine 2010).

There are many types of teacher communities, such as inquiry communities, teacher professional communities and communities of practice, each with a slightly different focus. Teachers in inquiry communities conduct systemic inquiry with colleagues to enhance teaching and learning in schools. Through protocol-guided discussions and identifying previously unexamined teaching gaps, tacit knowledge is made explicit (Levine 2010), urging teachers to formulate questions and develop tools that in the end lead to long-term change in their teaching practice (Levine 2010; Nelson and Slavit 2008). The success of teacher communities however depends heavily on teachers' willingness to openly share and discuss their teaching dilemmas and uncertainties with one another (Little 2012), which in general strengthens teachers' ability to collaborate, in addition to gaining insights via discussions.

6.3.3 Tools for Twenty-First Century Skills Development

This section aims to broaden teachers' repertoire of education technology for their own professional development and for application in class. Some tools specifically target one component of twenty-first century skills; the citation machine, for

example, helps heighten information literacy. Other tools can be applied to assist in the development of multiple competencies, for instance, social media facilitates communication as well as collaboration, while the ability to use the platform itself requires ML and IT literacy. Depending on the demands of the situation, teachers may consider using one or a combination of the following tools.

6.3.3.1 Information Literacy: Citation Guides and Citation Machines

The awareness for ethical use of sources and the ability to properly cite them is one of the aspects that students were found weak in Yeung et al. (2012). The problem of plagiarism is more common in second-language writing due to students' lower proficiency in the language (Pecorari 2003). Owing to the lack of practice, teachers themselves may not be familiar with systems available to deal with plagiarism.

A big milestone towards ethical use of sources is to be able to identify what constitutes plagiarism, as the main cause behind plagiarism is students not understanding citation rules and produce proper citations (Wilholt 1994; Landau et al. 2002). For this purpose, teachers may consult publishing manuals for various citation styles, like the APA style (APA 2001) for subjects or projects related to humanities. Admittedly, these publishing manuals may be too detailed for learners at primary or even secondary school levels. Nevertheless, they are the authoritative sources to refer to in case any questions arise. For convenience and easy comprehension, teachers may turn to the vast collection of online citation guides such as the official websites of individual citation styles and webpages written by universities. These websites provide a well-catalogd list of citation rules which teachers may adapt for their own classroom use. While students in primary and secondary school may have limited access to academic journals, sources such as newspapers and webpages are very often freely accessible and commonly used in their inquiry projects. The introduction to citation rules also offers a precious opportunity to acquaint students with the wide variety of sources they can use for their own information search.

Once students have grasped a basic idea of the methods of basic citations, teachers can assign inquiry-based tasks to students, either individual or group tasks, for them to practice and improve their citation techniques by learning to paraphrase, quote, and cite sources. Through practice students can gain experience in doing citations and advance their information literacy skills (Chu et al. 2010; Siu et al. 2014). In the process, citation machines and plagiarism checking software are tools that may guide students in combatting plagiarism. A citation machine generates citations in the chosen citation style. At the beginning stage of learning how to cite, one often makes mistakes in the citation format required. Using a citation machine helps avoid plagiarism one may not be aware of, and at the same time see examples of how sources are properly acknowledged (Siu et al. 2014). Teachers may first familiarize themselves with the operation of the software, then demonstrate how to use it in students' inquiry tasks. Apart from the citation format, other common types of plagiarism include inability to paraphrase and even direct copying of sources

(Siu et al. 2014). Citation checking websites thus serve as gatekeepers to check whether students have committed plagiarism. There are many websites that perform this function free of charge, and have a capacity sufficiently large for checking primary and secondary level work. By requiring students to submit their drafts for checking, teachers can monitor students' progress based on the evaluation report generated by the website, and decide how much more guidance students require to complete the task. With a large database and computed program, these websites check plagiarism more efficiently than manual evaluation, allowing teachers more time to give feedback and advice. Students also benefit from using citation checking websites. As the report denotes any act of intended or unintended plagiarism, they gain first-hand experience of correcting improper citations by revising their drafts before submission of the final version (Siu et al. 2014).

6.3.3.2 Information Technology Literacy and Media Literacy: Digital Storytelling

Digital storytelling incorporates multimedia elements such as images, audio- and video-files in the art of telling stories. This exercise aims to present information on a specific topic, usually revolving around a selected theme and often narrated from a particular viewpoint (Robin 2006). Digital stories produced for educational purposes can be categorized into three large groups, namely personal narratives of one's life events (Kajder 2004), historical documentaries that examine past events (Klaebe et al. 2007), and informative or instructive stories about concepts or practices (Andrews et al. 2009).

Both teachers and students may experience gains from the application of digital storytelling. It acts as an alternative instructional tool to PowerPoint presentations (Dogan and Robin 2008). So teachers may make good use of the multimedia nature of digital stories to capture students' attention, stimulate their interest in the topic (Burmark 2004), and as an entry point to bridge the transition from existing knowledge to the creation of new ideas (Kajder and Swenson 2004). With the help of digital storytelling, teachers may also help students envision and decipher the meaning of abstract texts (Kajder and Swenson 2004). This technique may have a similar effect on teachers—teachers have used digital storytelling not only in the classroom but also in cross-curriculum sharing with fellow teachers (Dogan and Robin 2008).

Other than being an instructional tool, digital stories may be used by students. In fact, digital stories are more frequently created by students than teachers, for example in making video yearbooks, field trip reports, and inquiry project presentations for various subjects (Dogan and Robin 2008). Students are motivated to participate in the making of digital stories, as they enjoy less academic and more creative forms of coursework (Dogan and Robin 2008; Sadik 2008). Digital storytelling can therefore be incorporated into the curriculum as a part of inquiry-based group projects, giving students ample opportunities to practice various twenty-first century skills. Students enhance their information literacy through performing a

search for information, images, and audio clips, become more competent in information technology skills after using software to edit photos or other multimedia components, as well as strengthen their media literacy as they put together the final product. The projects also provide meaningful opportunities for students to collaborate, and to think critically and creatively (Sadik 2008).

Just like other forms of inquiry-based learning, students require and benefit from teachers' assistance throughout the project. As digital storytelling involves the use of more information technology applications, the need for technical support is especially vital. Teachers may recommend different kinds of software for photo editing, sound editing and video editing etc., and demonstrate to students how to use these applications. Guidance in sketching the storyboard and writing the script may also be necessary, since a good digital story includes not only interesting ideas but also a thorough plan that considers all text, graphic, and sound components (Chung 2006).

6.3.3.3 Collaboration: Social Media

Scholars generally agree that social media functions as tools to connect with people through on-site communication in order to foster and maintain relationships, and establish communities of similar interest at ease (Trautschold et al. 2011; Boyd and Ellison 2008; Mayfield 2008). At present, there are numerous forms of social media enthusiastically accepted by the public. To name but one example, Facebook is a composite site for text and multimedia sharing. There are of course other multimedia sharing platforms such as Flickr, Instagram, and Youtube, as well as information-oriented social media like PBWorks and wikis.

It has been argued that the potential of social media in education has not been fully exploited (Chen and Bryer 2012) as it is primarily used for personal communication (Coyle and Vaughn 2008). There are five characteristics that distinguish social media from other forms of media, and make it suitable for both formal and informal learning. They are: user-generated content, prosumer, co-creation, sharing, and community. These affordances of social media make the media a user-friendly platform for teachers to collaborate. In fact, teachers have already been making use of wikis for resource sharing. Wikis created for this purpose occupy the highest percentage (40 %) among educational wikis in the U.S. (Reich et al. 2012). These wikis are unfortunately very often inactive ones with few and infrequent updates. To ensure the quality of wiki, one method is to promote its function as an online community for teacher professional development, co-created by fellow teachers. Wiki is acknowledged for its advantage over didactic forms of teacher instruction as it enables teachers to address the complexities of an actual classroom situation and to take ownership of their pedagogical ideas. If its capacity is fully utilized, it facilitates peer exchange of ideas as well as the sharing of experience and challenges (Foley and Chang 2008).

The ultimate goal of teacher development is to equip teachers with the necessary knowledge and skills that can enhance student learning. Wiki is equally, if not

more, applicable in student collaborative projects. Students hold a positive attitude toward wiki-assisted collaboration and their motivation to participate in group work is often seen to be boosted. Those who are more capable offer explanations to their less capable groupmates, and the help-seekers play an active role in interpreting the explanations received (Woo et al. 2011; Lui et al. 2014). In addition to attitudinal benefits, wiki has been proven to effectively facilitate group work by breaking down geographical and temporal barriers during collaboration. Students can contribute to the wiki contents regardless of time and venue (Woo et al. 2011).

6.4 Conclusion

In order to successfully implement twenty-first century skills pedagogies, teachers are adviced to first acquire the various components of twenty-first century skills so as to be able to freely deploy the most appropriate pedagogies in teaching and learning. We have identified in this chapter the twenty-first century skill components that teachers are relatively weak in, namely information literacy, information technology literacy, media literacy, and digital collaboration skills. Before mastering these skills, it may be immature to expect teachers to guide students through twenty-first century skills learning activities as many of these activities call for a wide range of skill components. Selected tools that may be useful in supporting twenty-first century pedagogies need to be introduced, each targeting one or more skill components. Citation guides and citation machines are effective in promoting ethical use of sources, and this is one important element of information literacy. Digital storytelling provides teachers and students with valuable chances to practice information technology skills and improve media literacy. The effect of social media in facilitating collaboration is also shown to be widely recognized. Finally, strategies that help teachers acquire twenty-first century skills are discussed. Teachers may consider participating in collaborative inquiry to gain first-hand experience of this pedagogy, partner with universities to benefit from the expertise of university academics and engage in teacher communities for peer support.

References

Andrews, D. H., Hull, T. D., & Donahue, J. A. (2009). *Storytelling as an instructional method: Descriptions and research questions*. Oak Ridge Institute for Science and Education.

[APA] American Psychological Association. (2001). *Publication manual of the American psychological association*. Washington DC: American Psychological Association.

Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 online distance educators in the United States. *Contemporary issues in technology and teacher education, 9*(1), 71–88.

Australian School Library Association. (2001). Learning for the future: Developing information services in schools (2nd edn.). Carlton, South Vic.: Curriculum Corporation.

Barone, D. (2012). Exploring home and school involvement of young children with Web 2.0 and social media. *Research in the Schools*, *19*(1), 1–11.

Baumfield, V., & Butterworth, M. (2007). Creating and translating knowledge about teaching and learning in collaborative school–university research partnerships: An analysis of what is exchanged across the partnerships, by whom and how. *Teachers and Teaching 13*, 411–427.

Bhalla, J. (2012). Study of barriers to use of computers by school teachers in teaching-learning process. *Journal of Educational and Social Research*, 259.

Boyd, D. M., & Ellison, N. B. (2008). Social network sites: Definition, history and scholarship. *Journal of Computer-Mediated Communication, 13*, 210–230.

Bray, J. N. (2002). Uniting teacher learning: Collaborative inquiry for professional development. *New Directions for Adult and Continuing Education, 2002*(94), 83–92.

Buckingham, D. (2002). *The media literacy of children and young people. A review of the research literature*. Centre for the Study of Children, University of London.

Burmark, L. (2004, May/June). Visual presentations that prompt, flash & transform. *Media and Methods, 40*(6).

Burnett, P. C. (2002). Teacher praise and feedback and students' perceptions of the classroom environment. *Educational Psychology, 22*(1), 5–16.

Butler, D. L., & Schnellert, L. (2012). Collaborative inquiry in teacher professional development. *Teaching and Teacher Education, 28*, 1206–1220.

Caverly, D. C., & Ward, A. (2008). Techtalk: Wikis and collaborative knowledge construction. *Journal of Developmental Education, 32*, 36–37.

Chen, B., & Bryer, T. (2012). Investigating instructional strategies for using social media in formal and informal learning. *The International Review of Research in Open and Distance Learning, 13*(1), 87–104.

Chu, S.K.W. (2010). A Journey of Teaching and Learning with Wikis. Paper presented at the *7th International Conference on Knowledge Management (ICKM2010)*. Pittsburgh, Pennsylvania, USA.

Chu, D., Chu, S.K.W., Tavares, N., Siu, F., Chow, K. & Ho, S. Y. (2010). *Media awareness in the age of new media: A case study of Primary 4 students in Hong Kong*. Paper presented at ASIS&T 2010 Annual Meeting. Pittsburgh, PA.

Chu, S. K. W., Lee, T. L. & King, R. B. (2012). *Writing with others in wiki: An investigation of student collaborative writing in English among Chinese secondary students*. Paper presented at DGI-Conference 2012, Germany.

Cook, M., Oliver, K., Pritchard, R., & Lee, S. (2014, March). using forum-based writing to learn in the english classroom: An investigation of student comprehension and collaboration. *Proceedings from Society for Information Technology & Teacher Education International Conference 2014. Chesapeake, VA: Association for the Advancement of Computing in Education (AACE).*

Cortez, C., Nussbaum, M., Woywood, G., & Aravena, R. (2009). Learning to collaborate by collaborating: A face-to-face collaborative activity for measuring and learning basics about teamwork. *Journal of Computer Assisted learning, 25*(2), 126–142.

Coyle C., & Vaughn, H. (2008). Social networking/communication revolution or evolution? *Bell Labs Technical Journal*, 13–18.

Christensen, R., & Knezek, G. (2008). Self-report measures and findings for information technology attitudes and competencies. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 397–417). New York: Springer.

Clark, K. (2006). Practices for the use of technology in high schools: A delphi study. *Journal of Technology and Teacher Education, 14*(3), 481–499.

Condie, R., & Livingston, K. (2007). Blending online learning with traditional approaches: Changing practices. *British Journal of Educational Technology, 38*, 337–348.

Chung, S. K. (2006). Digital storytelling in integrated arts education. *The International Journal of Arts Education, 4*(1), 33–50.

Dawson, V. (2008). Use of information communication technology by early career science teachers in Western Australia. *International Journal of Science Education, 30*, 203–219.

Dede, C., Ketelhut, D. J., Whitehouse, P., Breit, L., & McCloskey, E. (2008). A research agenda for online teacher professional development. *Journal of teacher education*.

Deni, A. R. M., & Malakolunthu, S. (2013). Teacher collaborative inquiry as a professional development intervention: benefits and challenges. *Asia Pacific Education Review, 14*(4), 559–568.

Dogan, B., & Robin, B. (2008, March). Implementation of digital storytelling in the classroom by teachers trained in a digital storytelling workshop. *Proceedings from Society for Information Technology & Teacher Education International Conference 2008*. Chesapeake, VA: Association for the Advancement of Computing in Education (AACE).

Drago-Severson, E. (2012). New opportunities for principal leadership: Shaping school climates for enhanced teacher development. *Teachers college record, 114*(3), 1–44.

Drent, M., & Meelissen, M. (2008) Which factors obstruct or stimulate teacher educators to use ICT innovatively?. *Computers and Education*, *51*(1), 187–199.

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education, 59*(2), 423–435.

Foley, B., & Chang, T. (2008). Wiki as a professional development tool. Paper presented at the *Society for Information Technology & Teacher Education International Conference 2008*, Las Vegas, Nevada, USA. http://www.editlib.org/p/27677.

Gawith, G. (1988). *Action learning: Student guide to research and information skills*. Wellington: Longman Paul.

Gess-Newsome, J., & Lederman, N. G. (1999). *Examining pedagogical content knowledge*. Dordrect, The Netherlands: Kluwer Academic Publishers.

Gray, L., Thomas, N. T., & Lewis, L. (2010). Teachers' use of educational technology in U.S. public schools: 2009 (NCES No. 2010040). Washington, DC: National Center for Education Statistics.

Harada, V. H., & Yoshina, J. M. (2004). *Inquiry learning through librarian-teacher partnerships* (pp. 3–5). Worthington, Ohio: Linworth Pub.

Harris, J. B., & Hofer, M. J. (2011). Technological pedagogical content knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on Technology in Education, 43*(3), 211–229.

Heick, T. (2013). *An Inquiry Framework: 5 Levels of Student Ownership* (TeachThought) Retrieved from: http://www.teachthought.com/learning/inquiry-framework-levels-student-ownership/

Hobbs, R. (2010). *Digital and Media Literacy: A Plan of Action*. Washington DC: Aspen Institute.

Hughes, J. E., & Ooms, A. (2004). Content-focused technology inquiry groups: Preparing urban teachers to integrate technology to transform student learning. *Journal of Research on Technology in Education, 36*(4), 397–411.

International Society for Technology in Education. (2008). *ISTE Standards: Teachers*. Retrieved 14 July from http://www.iste.org/docs/pdfs/20-14_ISTE_Standards-T_PDF.pdf

Ismail, I., Azizan, S. N., & Azman, N. (2011). Internet as an influencing factor of teachers' confidence in using ICT. *Malaysian Journal of Distance Education, 13*(61), 1–74.

Jaglom, L., & Gardner, H. (1981). The preschool television viewer as anthropologists. In H. Kelly & H. Gardner (Eds.), *Viewing children through television*. San Francisco: Jossey-Bass.

Kahveci, A., Sahin, N., & Genc, S. (2011). Computer perceptions of secondary school teachers and impacting demographics: A turkish perspective. *The Turkish Online Journal of Educational Technology, 10*(1), 71–80.

Kajder, S. B. (2004). Enter here: Personal narrative and digital storytelling. *English Journal*, 64–68.

Kajder, S., & Swenson, J. A. (2004). Digital images in the language arts classroom. *Learning and Leading with Technology, 31*(8), 18–21.

Keengwe, J., & Kang, J. J. (2013). Preparing in-service language teachers to design and implement technology-rich curriculum. *Education and Information Technologies, 18*(4), 609–619.

Kim, H. N. (2008). The phenomenon of blogs and theoretical model of blog use in educational contexts. *Computers & Education, 51*(3), 1342–1352.

Klaebe, H. G., Foth, M., Burgess, J. E., & Bilandzic, M. (2007). Digital storytelling and history lines: Community engagement in a master-planned development. In *Proceedings of the 13th International Conference on Virtual Systems and Multimedia: Exchange and Experience in Space and Place, VSMM 2007*. Australasian Cooperative Research Centre for Interaction Design Pty, Limited.

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60–70.

Kopcha, T. J. (2012). Teachers' perceptions of the barriers to technology integration and practices with technology under situated professional development. *Computers & Education, 59*(4), 1109–1121.

Korobili, S., Malliari, A., Daniilidou, E., & Christodoulou, G. (2011). A paradigm of information literacy for Greek high school teachers. *Journal of Librarianship and Information Science, 43* (2), 78–87.

Landau, J. D., Druen, P. B. & Arcuri, J. A. (2002). Methods for helping students avoid plagiarism. *Teaching of Psychology*, *29*, 112–115.

Law, N., Pelgrum, W. J., & Plomp, T. (2008). Pedagogy and TECHNOLOGY use in schools around the world. Findings from the IEA SITES 2006 study. CERC Studies in comparative education. Hong Kong: Comparative Education Research Centre, The University of Hong Kong, and Dordrecht: Springer.

Leithwood, K., Leonard, L., & Sharrat, L. (2000). Conditions fostering organizational learning. In K. Leithwood (Ed.), *Understanding schools as intelligent systems* (pp. 99–124). Stamford, CT: JAI Press.

Levine, T. H. (2010). Tools for the study and design of collaborative teacher learning: The affordances of different conceptions of teacher community and activity theory. *Teacher Education Quarterly, 37*(1), 109–130.

Liu, K.Y. (2011). Enhancing prospective teachers' critical reflection in the ePortfolio environment. Ph.D. thesis, Madison: The University of Wisconsin.

Little, J. W. (2003). Constructions of teacher leadership in three periods of policy and reform activism. *School Leadership & Management, 23*(4), 401–419.

Little, J. W. (2012). *Professional community and professional development in the learning-centered school* (pp. 22–46). Teacher learning that matters: International perspectives.

Lomos, C., Hofman, R. H., & Bosker, R. J. (2011). Professional communities and student achievement–a meta-analysis. *School Effectiveness and School Improvement, 22*(2), 121–148.

Lui, W. T. V., Lau, W. W. F., & Chu, S. K. W. (2014). *Using social media tools in the learning and teaching of General Studies in primary school: An inquiry-based approach*. Paper presented at the *CITE Research Symposium 2014*, The University of Hong Kong, Hong Kong.

Mayfield, A. (2008). *What is Social Media?* UK: iCrossing. Retrieved December 5, 2011, from http://www.icrossing.co.uk/fileadmin/uploads/eBooks/What_is_Social_Media_iCrossing_ebook.pdf

McDonald, M., Kazemi, E., & Kavanagh, S. S. (2013). Core practices and pedagogies of teacher education a call for a common language and collective activity. *Journal of Teacher Education, 64*(5), 378–386.

Merchant, L., & Hepworth, M. (2002). Information literacy of teachers and pupils in secondary schools. *Journal of Librarianship and Information Science, 34*(2), 81–89.

Nelson, T. H., & Slavit, D. (2008). Supported teacher collaborative inquiry. *Teacher Education Quarterly*, *35*(1), 99–116.

Ottenbreit-Leftwich, A. T., Glazewski, K. D., Newby, T. J., & Ertmer, P. A. (2010). Teacher value beliefs associated with using technology: Addressing professional and student needs. *Computers & Education, 55*(3), 1321–1335.

Ottenbreit-Leftwich, A. T., Brush, T. A., Strycker, J., Gronseth, S., Roman, T., & Abaci, S. et al. (2012). Preparation versus practice: How do teacher education programs and practicing teachers align in their use of technology to support teaching and learning? *Computers & Education*, *59*(2), 399–411.

[P 21] Partnership for 21st Century Skills. (2009). *P21 Framework Definitions*. Retrieved 4 July, 2014 from http://p21.org/storage/documents/P21_Framework_Definitions.pdf

Pecorari, D. (2003). Good and original: Plagiarism and patchwriting in academic second-language writing. *Journal of Second Language Writing, 12*(4), 317–345.

Prensky, M. (2001). Digital natives, digital immigrants Part 1. *On the Horizon*, *9*(5), 1–6.

Probert, E. (2009). Information literacy skills: Teacher understandings and practice. *Computers & Education, 53*(1), 24–33.

Rapporteur, M. H. (2010), Exploring the intersection of science education and 21st century skills: A workshop summary. National Research Council (US) Board on Science Education. Washington (DC): National Academies Press (US).

Reich, J., Murnane, R., & Willett, J. (2012). The state of wiki usage in US k–12 schools leveraging web 2.0 data warehouses to assess quality and equity in online learning environments. *Educational Researcher, 41*(1), 7–15.

Richards, C. (2006). Towards an integrated framework for designing effective ICT-supported learning environments: The challenge to better link technology and pedagogy. *Technology, Pedagogy and Education, 15*(2), 239–255.

Riel, M., & Becker, H. J. (2008). Characteristics of teacher leaders for Information and Communication Technology. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 397–417). New York: Springer.

Robin, B. (2006, March). The educational uses of digital storytelling. *Proceedings from Society for Information Technology & Teacher Education International Conference 2006*. Chesapeake, VA: Association for the Advancement of Computing in Education (AACE).

Rummel, N., & Spada, H. (2005). Learning to collaborate: An instructional approach to promoting problem-solving in computer-mediated settings. *The Journal of the Learning Sciences, 14*(2), 201–241.

Sadik, A. (2008). Digital storytelling: A meaningful technology-integrated approach for engaged student learning. *Educational Technology Research and Development, 56*(4), 487–506.

Safar, A. H., & AlKhezzi, F. A. (2013). Beyond computer literacy: Technology integration and curriculum transformation. *College Student Journal, 47*(4), 614–626.

Sandholtz, J. H. (2001). Learning to teach with technology: A comparison of teacher development programs. *Journal of Technology and Teacher Education*, *9*(3), 349–374.

Sandholtz, J. H. (2002). Inservice training or professional development: Contrasting opportunities in a school/university partnership. *Teaching and Teacher Education, 18*(7), 815–830.

Sandholtz, J., Ringstaff, C., & Dwyer, D. C. (1997). *Teaching with technology: Creating student-centered classrooms*. New York: Teachers College Press.

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological Pedagogical Content Knowledge (TPACK) the development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education, 42*(2), 123–149.

Siu, F. L. C., Chan, R. C. H., Law, O. K. L., & Chu, S. K. W. (2014). Plagiarism-free inquiry learning. Paper presented at the *CITE Research Symposium 2014*, The University of Hong Kong, Hong Kong.

Smith, J. K. (2013). Secondary teachers and information literacy (IL): Teacher understanding and perceptions of IL in the classroom. *Library and Information Science Research, 35*, 216–222.

Trautschold, M., Mazo, G., & Karch, M. (2011). *Droid made simple: for the droid, droid x, droid 2 and droid 2 global*. New York: Springer Science Business Media.

Voogt, J. (2010). Teacher factors associated with innovative curriculum goals and pedagogical practices: differences between extensive and non-extensive ICT-using science teachers. *Journal of Computer Assisted learning, 26*(6), 453–464.

Wilholt, S. (1994). Helping Students Avoid Plagiarism, *College Teaching*, *42*(4), 161–164.
Whitehouse, P., Reynolds, R., & Caperton, I. (2009, March). Globaloria Pilot Year One: New Directions for 21st Century Teacher Professional Development. *Proceedings from Society for Information Technology & Teacher Education International Conference 2009. Chesapeake, VA: Association for the Advancement of Computing in Education (AACE).*
Williams, D. A., & Wavell, C. (2007). Secondary school teachers' conceptions of student information literacy. *Journal of Librarianship and Information Science, 39*, 199–212.
Wilson, A., & Christie, D. (2010). Realising the potential of virtual environments: A challenge for Scottish teachers. In J. Lindberg & A. Olofsson (Eds.), *Online learning communities and teacher professional development: Methods for improved education delivery* (pp. 96–113). PA: Hershey.
Windschitl, M. (2009). *Cultivating 21st century skills in science learners: How systems of teacher preparation and professional development will have to evolve*. Paper prepared for the Workshop on Exploring the Intersection of Science Education and the Development of 21st Century Skills, National Research Council. Retrieved from http://www7.nationalacademies.org/bose/WindschitlPresentation.pdf
Woo, M., Chu, S., Ho, A., & Li, X. X. (2011). Using a Wiki to Scaffold Primary School students' collaborative writing. *Journal of Educational Technology & Society, 14*(1), 43–54.
Yeung, A. H. W., Chu, C. B. L., & Chu, S. K. W. (2012). Explore the behavior of plagiarism at the secondary school level in Hong Kong. Paper presented at *CITE Research Symposium 2012*, The University of Hong Kong, Hong Kong.
Zeichner, K. (2012). The turn once again toward practice-based teacher education. *Journal of Teacher Education, 63*(5), 376–382.
Zeichner, K. M. (2003). Teacher research as professional development for P–12 educators in the USA [1]. *Educational Action Research, 11*(2), 301–326.

Chapter 7
Guides and Suggestions for Classroom Implementation

This chapter offers pragmatic and pedagogical design recommendations for carrying out inquiry-based learning interventions to inculcate twenty-first century skills in young people. Suggestions made in this chapter center on the inquiry project-based learning (inquiry PjBL) protocol described by Chu et al. (2012b) as well as some other similar models currently in practice. This chapter brings to the fore particular roles that are expected of teachers who adopt such an approach, and presents case studies of specific activities used at a variety of grade levels and in different subject domains. Timetables are provided to illustrate possible scope and sequence details, highlighting the functions of collaborating teachers and school librarians. While several other pedagogies are addressed in the book, the general principles of this chapter as applied to Chu et al.'s protocol may be adapted. Areas that may be modified by educators, considering variation in one's given implementation context, will also be discussed. This chapter aims to lay out guidelines that can be directly applied by those who wish to try out such models in their own environments.

7.1 Step-by-Step Guide to the Implementation of Inquiry PjBL in the Classroom

There are five main considerations for teachers who wish to initiate a trial practice of inquiry group PjBL at school, namely, teachers' readiness, students' readiness, the inquiry design process, implementation strategies, and assessment mechanisms. These aspects must be carefully planned and reviewed—with a focus on the need to take into account contextual demands and hence school-based modifications—for the implementation to be successful, and for the stated learning goals and objectives to be met.

S.K.W. Chu et al., *21st Century Skills Development Through Inquiry-Based Learning*, DOI 10.1007/978-981-10-2481-8_7

7.1.1 Teachers' Readiness

Nothing is more important than a teacher's readiness and confidence when trying out a new initiative in education. While the concept of inquiry-based learning stresses the role of teachers as facilitators rather than instructors, it is critical that teachers understand that facilitation does not mean adoption of a laissez-faire hands-off approach. Inquiry-based learning can be equated to student-centered learning. If anything, this technique requires teachers to be even more familiar with their individual students' levels of learning and needs in order to contextualize instructions in their appropriate zone of proximal development (Vygotsky 1978). Teaching skills in relation to counseling and coaching, facilitation, co-learning, and teaming with colleagues are essential in guiding students in their learning process (Harada et al. 2008). Through professional training, teachers can acquire these sets of skills needed for introducing inquiry-based learning projects to their students. Related discussions and suggestions on professional development and training activities have been addressed in Chap. 6.

7.1.1.1 Pre-class Collaboration with Colleagues

Inquiry-based learning strongly emphasizes collaboration among teachers, school librarians and other members of the instructional team, all of whom contribute in their respective areas of expertise (Chu 2009; Crawford et al. 2005; Harada and Yoshina 2004; Harada et al. 2008; Kuhlthau et al. 2007; Paechter 1995). Studies have shown that the impact of project-based learning can be enhanced by effective teacher collaboration. Favorable outcomes include overall improvement in student achievement, less disruptive student behavior, decreased numbers of referrals due to behavioral problems, less paperwork for teachers, and more students meeting the criteria for gifted and talented education services (Schwab Learning 2003). With project-based learning, teachers have also been observed to be better prepared to meet the needs of students from diverse backgrounds (Thousand et al. 2006). For example, in Kuhlthau's Guided Inquiry approach, having a three-member core team plan and supervising the inquiry is recommended, with an extended team of other experts joining when they are needed (Kuhlthau and Maniotes 2010). Five kinds of learning in the inquiry process are given emphasis, as listed below (Table 7.1).

Case study scenarios are presented, considering role-taking in flexible teams, for both a core team comprising the school librarian and two subject teachers, and for an extended team of outside experts, as Table 7.2 shows.

Table 7.3 displays the various responsibilities of the team members in one of their case study examples. While X1 represents a primary area of focus (e.g., observation, note taking and assessing), X2 represents a second area. In the study, all team members worked together to monitor students' learning process. Their documented observations of students' growth and development were discussed at team meetings. The Reading Specialist or Classroom Teacher (appropriate to an

Table 7.1 Five kinds of learning in the inquiry process (adopted from Kuhlthau and Maniotes 2010)

Key learning areas	Skills
Curriculum content	Gaining knowledge, interpreting, and synthesizing
Information literacy	Locating, evaluating, and using information
Learning how to learn	Initiating, selecting, exploring, focusing, collecting, presenting and reflecting
Literacy competence	Reading, writing, speaking, listening, and viewing
Social skills	Cooperating, collaborating, flexibility, and persistence

Table 7.2 Flexible teams (adopted from Kuhlthau and Maniotes 2010)

What?	Who?	How?	When?
Core team	Librarian, Subject Area Teacher + 1 +1 = learning specialist: gifted, learning disabilities, etc.	Flexible depending on • Unit/curricular needs • Students' interest • Learning needs Focus on five kinds of learning Assess all levels of learning	From beginning of planning (conception) to final reflection (completion)
Extended team	Experts on learning Experts on content	Assist with literacy needs, learning needs and differentiation Museum, local/community, wider community—Internet-based, university	Dipping in and out as needed throughout the inquiry process

Table 7.3 Instructional team task (adopted from Kuhlthau and Maniotes 2010)

5 Kinds of learning	School librarian	Reading specialist	Classroom teacher
Science content			X1
Information literacy	X1		
How to learn (information search process)	X1		
Literacy		X1	X1
Social skills	X2	X2	X2

elementary school) may be interchanged with other kinds of subject matter experts such as a Social Studies teacher and a Science teacher at middle school or high school level, depending on the target student population (Kuhlthau and Maniotes 2010).

The basic principles of collaborative team teaching sourced from Kuhlthau et al.'s (2010) Guided Inquiry model emphasize close coordination of team members from the very early stages of intervention, to yield effective inquiry PjBL.

The formation of a strong instructional team starts with the selection of its team members. The team then needs to align members' expectations, and decide on the key learning objectives and learning outcomes (Harada et al. 2008; Kuhlthau et al. 2007). It is advisable that the responsibilities of each member be clearly defined to avoid overlaps or gaps in delivering knowledge or skills to students (Chu et al. 2012a; Harada and Yoshina 2004; Kuhlthau et al. 2007).

The next step is to identify areas of collaboration (Harada and Yoshina 2004). For example, the school librarian may teach students how to conduct an information search on the topic assigned by the subject teacher who has already offered some up-front instruction. Once roles are established, teachers can start designing the curriculum and, on this basis, devising activity outlines and assignments. Teachers of different subjects may contribute to the decision of method and timing of the delivery as well as the form of the assignment in various subjects (Chu 2009; Harada and Yoshina 2004; Kuhlthau et al. 2007; Paechter 1995). The teaching schedule and subsequent evaluation processes could be set afterwards (Chu et al. 2012a; Harada et al. 2008).

These team-based approaches require ongoing communication among the educators involved, and may include face-to-face planning sessions, coordinating phone calls, emails, use of shared learning management system platforms that may be in place at school, and even text messaging among the parties, for basic logistics. Shared understanding of learning goals and objectives, and keeping oneself abreast with and "in sync" on the instructional progress is key to close team-based communication. Nevertheless, certain in situ changes and modifications are often necessary, quite common, and to be expected. (Kuhlthau and Maniotes 2010).

7.1.2 Students' Readiness

When teachers' readiness for the implementation of inquiry-based learning is ensured, the team can then find ways to guarantee that students are prepared for the challenge. Research findings have suggested that the learning design may present students with a moderate degree of challenge if effective learning is to be sought (Sousa 2001; Wolfe 2001), and so refraining from presenting materials too far beyond students' level, which may result in confusion and frustration (Byrnes 1996), is believed to be helpful.

Scholars generally propose a gradual step-up in the complexity of inquiry learning tasks. Students' knowledge and understanding of relevant information-seeking concepts and principles should be periodically assessed and inventoried, while taking into consideration their social, affective and metacognitive needs. Available instruments include Arnone et al.'s (2009, 2010) diagnostic surveys, which measure students' self-efficacy and prior motivation as predictors for success. These surveys can be administered before and after the delivery of the intervention, and can be used to identify students who may need extra attention. Teachers should also consider students' experience in resource management and

their information literacy skills (Harada et al. 2008). Based on students' mastery in these domains, teachers can decide which mode of inquiry to adopt. Heick (2013) advocates an inquiry framework grounded on the levels of student agency, in which students, as they advance in their acquisition of relevant knowledge and skills, are allowed increasing freedom in their choice of research questions, study methods, data collection and analysis processes, and presentation mode. Educators must be well aware of students' existing expertise, given that novices require more structured learning experiences. As facilitators to the inquiry, educators will need to personalize instruction as much as possible to ensure potentially more successful learning outcomes.

7.1.3 Inquiry Design Process

In addition to taking appropriate steps to make sure that both teachers and students are mentally and conceptually ready for inquiry-based learning, the instructional team should carefully design the inquiry mode in order to maximize its effectiveness. It is important to plan according to curriculum expectations and students' ability (Byrnes 1996; Tomlinson et al. 2003). As this guided project-based inquiry learning approach spans across a period of time, each lesson or session must be developed in advance and reviewed regularly to ascertain that the learning process is well-paced.

Kuhlthau et al.'s (2012) eight-step guided inquiry design (GID) process is particularly useful in illuminating teachers on what actions to take when carrying out guided inquiry at school. Although their framework is theoretical in nature, when combined with Harada's examples of project-based learning design (Harada and Yoshina 2004; Harada et al. 2008), it becomes a very practical guide to teachers. Below is a table which synthesizes their work, incorporating added task suggestions (Table 7.4).

As different projects may have diversified subject matter and information/digital literacy learning objectives, the length of the projects will vary. Some projects may have a duration as short as 2 weeks (Gibson and Chase 2002) while others may last for months (Chu et al. 2008; Chu et al. 2012a).

Factors and contingencies that can be adjusted and fine-tuned include

- Students' grade level and cognitive/affective/behavioral capacities
- Findings of the up-front diagnostic needs inventory (e.g., surveys such as those developed by Arnone et al. 2009, 2010)
- The timeline and duration of the project in the block schedule, or even after school
- The project's content-based learning goals—considering the nature and scope of the inquiry topic and its relationship with core curricular standards and classroom learning goals
- Appropriate allocation of time needed for information literacy expertise

Table 7.4 Eight-step design process for "guided project-based inquiry" (a synthesis of Kuhlthau et al.'s GID model (2012) and Harada et al.'s (2008) and this book's authors' recommendations)

Learning goal	Instructor's task	Student performance task
Stage One: Opening		
• Introducing the project • Setting the scene and direction • Arousing students' curiosity • Establishing the topic domain	• To introduce the project goals • To introduce a broad topic • To arouse students' curiosity • To facilitate student interaction and clarify misconceptions	• To interact with the educator to develop a shared understanding of the project and its goals, and the primary topic domain • To collaborate with peers in addressing the given question prompts • To write a short reflection individually, followed by group sharing
Stage Two: Immersion		
• Reflection on the topic • Building of background knowledge • Connecting ideas to content • Guiding further investigation into the issue	• To encourage student input and questioning, and offer perspectives that help redirect students along appropriate paths of inquiry • To acclimatize students to available resources	• To build personal meaning into the project through connection with a personal linkage • To understand key resources provided • To discuss the issues and key concepts
Stage Three: Exploration		
• Allowing students to pursue interesting ideas through initial phase of exploratory research and review of resources	• To conduct library instructional sessions on basic research methods • To facilitate student interaction with resources, creation of inquiry logs and idea sharing with peers	• To browse information from books, journals, periodicals, videos and credible websites • To keep an inquiry log and share ideas discovered with the class
Stage Four: Identification		
• Identification and construction of important inquiry questions based on students' background knowledge • Formation of groups for further investigation into the inquiry questions	• To guide student research question formulation at the individual level • To list issues identified for students' selection of topic and project group formation • To revisit the project goals and next steps	• To identify issues and share ideas by referring to the inquiry journal and log • To select a topic, either individually or with 2–3 classmates and come up with a clearly articulated focus inquiry question
Stage Five: Searching		
• To conduct research through locating, evaluating and using information that leads to creation and deeper learning	• To teach students how to locate, evaluate and utilize information • To facilitate student interpretation and synthesis of a wide range of information	• To search for and record information that is specific to their inquiry questions, and learn new information-seeking skills while doing so

(continued)

Table 7.4 (continued)

Learning goal	Instructor's task	Student performance task
• To refine and develop research skills through the ongoing guidance of the school librarian	• To help students broaden/narrow their scope if needed, and guide them along more fruitful paths of inquiry	• To evaluate primary sources collected according to the criteria established • To organize and compile, then analyze and interpret the information, either individually or together with the team
Stage Six: Creating and Evaluating		
• Students construct deeper understanding through summarizing, interpreting and extending the information to draw some conclusions • Through effective expression of a message of their own regarding the topic in a creative artifact, students demonstrate their knowledge and learning	• To encourage students to go beyond fact-finding and move into deeper synthesis and reflection • To give feedback accordingly • To introduce possible formats of presentation and provide technical assistance when necessary	• To develop and construct the central message for their artifact based on research • To formulate the design and an action plan for their presentation, and to organize and project-manage this work accordingly • To conduct regular peer evaluations • To submit their group's draft for feedback and revision
Stage Seven: Sharing		
• Students effectively communicate and share the product they have created with other students and/or a wider audience • Students learn from one another's presentations demonstrating distributed cognition	• To give encouragement to students who lack confidence in and are unfamiliar with presenting their ideas in front of others • To observe, evaluate and give constructive feedback for student improvement • To create opportunities for all students to give feedback to presenting groups • To draw out and compile interesting ideas in each presentation and discuss them with students	• To present their findings to the teacher and their classmates • To give feedback to their peers, learn from one another's comments, and self-reflect • To participate in a discussion for evaluation of their own group's performance in the presentation through oral and written reflection

(continued)

Table 7.4 (continued)

Learning goal	Instructor's task	Student performance task
Stage Eight: Evaluation		
• Students will receive feedback through effective communication with educators, and identify ongoing areas for continued growth • Students will participate in self-assessment to more fully internalize their areas of strength and weakness	• To set up a conference with each student to guide them in their self-assessment • To design rubrics and self-reflection worksheets as tools to evaluate students' learning progress and assign grades for the work • To discuss students' performance with the team for the team's own evaluation	• To discuss with teachers their performance throughout the inquiry learning process and what they feel about it • To complete the self-reflection worksheets for self-evaluation on both the content learnt and the learning process

- Appropriate target audience for students' presentations. Examples of audience are classmates, younger or elder schoolmates, parents, teachers, external guests, their local community or even a group of overseas visitors (Kuhlthau et al. 2012).
- The medium of the creative project presentation (e.g., a research paper, an animated presentation, a narrated digital video, a narrated screencast of slides)
- Appropriate allocation of time as needed for building students' technical expertise for artifact creation
- Appropriate allocation of time for ongoing formative evaluation, feedback, and re-drafting
- Appropriate timing and planning needed to schedule formal and/or informal sharing of students' final work

Ensuring feasibility and an appropriate level of challenge is central to the success of a project. Flexible planning in the inquiry design process is encouraged too (Anderson 2002; Harada and Yoshina 2004; McLoughlin and Oliver 2000). In a flexible design, formative assessment plays a crucial role in determining whether adjustments have to be made to the original teaching plan. Although there is an "evaluation" stage at the end, it is desirable to set aside short reflection slots at the end of each stage to allow students time to process and internalize their learning, and discover areas of strength and weakness (Harada et al. 2008; Kuhlthau et al. 2012). Self-reflection is a critical part in the process of inquiry learning to motivate self-learning and monitor students' learning progress. Assessment may come in the form of students' journals, teachers' observations, peer evaluations, etc. When teachers realize that some students are not on the right track, they need to make changes accordingly (Harada and Yoshina 2004). For example, if teachers observe that students may not have mastered keyword searching skills during an exploratory information research session in the library, they can arrange for the library media specialist to spend another session on keyword search with the

students (Harada and Yoshina 2004). It is through regular evaluation and careful observation that teachers can discern patterns in students' behavior and performance, and make timely and appropriate changes to their teaching plans to accommodate students' needs and keep track of their progress. This is essential in meeting the learning objectives of a course.

7.1.4 Strategies for Teaching and Learning

After the instructional team has put together a detailed plan of the inquiry process, implementation is ready. Apart from the learning objectives defined by the team for the overall project, there should be general goals to be achieved in each session in collaboration with students. Efforts from both teachers and students have to be exerted to meet these targets in project-based learning. Harada et al. (2008) categorized these goals in accordance with students' rigor, relevance, relationships and reflection—termed the 4R's—in relation to their performance in the project, each with examples of strategies to help students accomplish the goals. The 4R's are general goals that teachers should strive for in their teaching. Strategic examples under each category comprise teacher–student interaction and sometimes cooperation among fellow teachers. Kuhlthau et al. (2007) further put forward a series of intervention strategies named the 6C's—collaborate, converse, continue, choose, chart and compose—to be adopted in class to facilitate student learning and to fulfill the designated learning objectives of each session. The 6C's focus primarily on interventions that are potentially of use to individual teachers in guiding students' inquiry learning. Teachers are reminded that learning activities of a different nature require the deployment of varying combinations of strategies suited to the purpose, and that it may not be desirable to be too ambitious to employ all the strategies in every teaching session.

7.1.4.1 Teacher–Librarian Collaboration

The effectiveness of project-based learning can be ensured and enhanced by the joint effort of education practitioners (Schwab Learning 2003; Thousand et al. 2006), as discussed in Sect. 7.1.2. In particular, collaboration between teachers and librarians in the implementation of inquiry learning has gained considerable attention in the past decade (Chu 2009; Chu et al. 2012b; Gordon 2006; Montiel-Overall 2008). Librarians are considered to be salient figures in developing students' information literacy in the regular curricula (Montiel-Overall 2008); they are referred to as the pedagogical center of student learning (Todd 2012). Several models of collaborative teaching highlight the cooperation between teachers and librarians, including the Teacher and Librarian Collaboration Model (TLC Model) by Montiel-Overall (2005) and the inquiry PjBL model by Chu (2009). Policy makers also value

teacher–librarian partnerships. Some countries, for instance Hong Kong, attach a high level of importance to the school library. The latest curriculum guide published by the Education Bureau (the largest education policy maker of Hong Kong) has devoted an entire chapter to the role of the school library. The guide (Education Bureau 2014) stresses the significance of a strong teacher–librarian partnership and the librarian's role as curriculum facilitator.

The TLC Model (Montiel-Overall 2005) gives weight to aspects to which teachers and librarians should pay particular attention in the collaboration process. In the model, both parties work closely together to promote students' academic achievement. The model identifies four facets of joint effort—coordination, cooperation, integrated instruction and integrated curriculum. Activities in these facets range from low-level to high-end collaborative endeavors, which require shared thinking and planning in some cases. Specifically, while coordination hinges on effective schedule management, cooperation involves the division of responsibilities. Integrated instruction and integrated curriculum would count on the team's concerted effort in planning, implementing and evaluating instruction strategies in lessons and across schools (Montiel-Overall 2005). A further examination of the model reveals that factors such as school culture, positive attributes of the collaborators, communication, management and motivation are main elements that facilitate high-end collaboration between teachers and librarians (Montiel-Overall 2008).

The inquiry PjBL model proposed by Chu et al. (2012b) comprises three types of subject teachers, each offering expertise in their respective areas, with the support of the school librarian. The model (shown in Fig. 3.1) is adapted for a General Studies (GS) group project, which will be explored in the second part of the chapter.

The role of school librarians is strongly advocated by scholars worldwide. Todd (2012) maintains that librarians function as co-teachers, and this view is supported by the testimonials of teachers and librarians participating in his study. Todd promotes the teaching role of school librarians as being visible and pervasive. With the school librarian's participation, the library becomes a pedagogical center that provides an active and common instructional zone for the whole school. Librarians also offer resource-centered, inquiry-based instruction that makes the library the heart of inquiry-based learning. Librarians' expertise in information search has been seen to reinforce subject teachers' instruction, apart from the provision of teacher professional development, fostering a more solid teacher–librarian collaboration.

7.1.5 Evaluation Mechanisms

Reflection is an integral part of the entire inquiry design process (Cachia et al. 2010). This is a stage that enables students to consolidate what they have learnt in each

session. With reflection, teachers are able to keep track of students' learning progress and make the necessary modifications to better accommodate their needs (Ferrari et al. 2009). As assessment strategies are to be discussed in detail in Chap. 8, this section only gives a brief review of current forms and tools of assessment.

Education practitioners utilize a wide variety of tools for the purpose of assessing student performance, including but not limited to the following examples. A common tool used is rubrics (Crawford et al. 2005; Kishbaugh et al. 2012), which are made up of indicators showing different levels of achievement, with each standard covering some essential qualities that students should possess after a certain intervention (Crawford et al., 2005). A checklist, which contains a set of criteria, targets and desired outcomes, is often used due to its easy administration and limited assessment time (Zohrabi et al. 2012). Learning logs can also be used as they create an avenue for students' self-evaluation (Lombardi 2007) of their work matched against the learning goals set in an earlier phase of the project (Commander and Smith 1996). Other tools include portfolio review (McMullan 2003), self-assessment (Lee and Gavine 2003) and peer review (Lombardi 2007). These tools may be used separately or in combination, and teachers may decide which tools to choose based on how well they reflect students' skills in a particular project (Walsh 2009).

7.2 Case Study on Collaborative Teaching and Inquiry PjBL Learning

This section offers suggestions on how inquiry PjBL and English collaborative writing using Web 2.0 (mainly wikis) can be carried out, using the example of an intervention designed for Hong Kong students with basic prior experience in collaborative projects. The plan presented in the chapter is the second phase of a two-year intervention (Chu et al. 2012b). In the first year, primary four students (aged 9–10) involved in the study in Hong Kong were guided in developing some essential skills for inquiry learning, such as reading and writing, and knowledge on the use of visual forms of presentation (e.g., Microsoft Powerpoint). In the second year, the students were introduced to social media, which is used as a platform for their collaboration projects. In particular, a General Studies (GS) project conducted in Chinese, the students' first language, was completed in the first term of the school year, followed by a wiki-based English collaborative writing project implemented in the second term.

An integrated timetable serves as a reminder that brings out the importance of collaborative teaching, and illustrates how teachers may operationalize their teaching plan. The roles of various subject teachers in inquiry PjBL using a

Table 7.5 The integrated teaching timetable of the 1st term (second year of intervention) put forward by Chu et al. (2012b, p. 82)

Week	General studies	Library lesson	English	Chinese	Computer studies
1				Reading Comprehension Assessment[a] 1 (Expository + Narrative)[b]	Use of wiki (e.g., Google Sites, PBworks)
2				Writing Assessment 1	
3				Literacy training[c] 1	
4	KWL[d] 5W + 1H Mind-mapping Self-reflection 1			Literacy training 2	
5		A review of strategies and skills for library and web searching (optional)	Collaborative writing (using pen and paper)	Literacy training 3	Use of wiki (e.g., Google Sites) (optional)
6	Groupings, topic selection and information search				
7	Information search and uploading the references onto the wiki				
8					
9	Self-reflection 2 (optional) Information analysis and report writing				
10					
11	Oral presentations (Students are encouraged to prepare for their presentations using wiki)				

(continued)

Table 7.5 (continued)

Week	General studies	Library lesson	English	Chinese	Computer studies
12	Organizing an exhibition for students' parents, students in junior forms and the community (optional)				
13	Self-reflection 3				

[a]The reading/writing assessments are meant to assess students' existing reading/writing abilities before starting the inquiry group projects so that schools and teachers can evaluate the effectiveness of the inquiry PjBL approach in strengthening their students' reading/writing abilities. Besides, it is recommended that teachers go through the answers of these assessment tasks with students shortly after they have been administered so students can learn from their mistakes
[b]The reading comprehension assessment used in Chu et al. (2012) consisted of one piece of narrative writing and an expository passage similar to those in the format of PIRLS, an international reading assessment organized by the International Association for the Evaluation of Educational Achievement (IEA). PIRLS focuses on the two main purposes of reading: reading for literary experience and reading to acquire and use information (Mullis et al. 2009)
[c]Literacy training is designed to develop students' reading comprehension and writing abilities. In the Chu et al. (2012) study, students were presented with a passage and required to identify the topic sentences of each paragraph and summarize the key ideas of the text in around 100–150 words
[d]KWL refers to What do I *K*now?, What do I *W*ant to know?, and What did I *L*earn?; 5W + 1H represents the six question words: who, when, where, what, why, and how

Table 7.6 The integrated teaching timetable of the 2nd Term (second year of intervention) outlined in Chu et al. (2012b, p. 83)

Week	General studies	English	Library lesson	Chinese	Computer studies
1				Reading Comprehension Assessment 2	
2				Writing Assessment 2	
3			WiseNews Library catalog search Web searching skills (searching for English resources)		
4					
5		English reading and writing assessment[a] (pre-test)			
6		Self-reflection 1			Teachers can decide on the content according to students' ability
7		Collaborative writing on wiki			
8					
9					
10		Self-reflection 2			
11		English reading and writing assessment (post-test)			

[a]English reading and writing tests are meant to evaluate students' abilities in the respective areas, with the aim of comparing their performance before and after collaborative writing using wiki

collaborative approach are exemplified using integrated timetables. Specific timetables for subject teachers are shown in the chapter (see Tables 7.5 and 7.6) to help educators visualize the learning activities associated with the teaching aims spelled out.

7.2.1 *Suggested Timetable for Collaborative Teaching and Inquiry PjBL (Second Year of Intervention)*

Upon completion of the first year of the inquiry PjBL project, it is expected that students should be more ready to search for relevant information independently and to present it more effectively using visual aids (e.g., Microsoft PowerPoint). Their reading and writing, IL and ICT skills should also have been cultivated and sharpened through collaborative teaching. In the second year, teachers are encouraged to continue to strengthen these skills. Specifically, ICT literacy may now include the use of wiki while language lessons may be devoted to engaging students in group tasks in the context of collaborative writing. It is also highly likely that GS group projects may be implemented at a greater depth, investigating a different subject matter either in the students' native language or even in a second language using a broader range of information sources. Presentation of students' work may become more sophisticated with the use of PowerPoint and different media forms (e.g., audio and video files). With students' growth in knowledge and skills in other areas, the language teacher may also consider introducing collaborative writing as a task or in students' second language they are learning for further language development.

Tables 7.5 and 7.6 below illustrate an integrated timetable for the first and second term of teaching, respectively. In the first term, students are expected to work on their inquiry group projects that aim to recapitulate the knowledge and skills acquired in the first year. To support the inquiry projects, students may be taught the basic skills of using a wiki platform. Meanwhile, they can start working on collaborative writing in a pen and paper format to experience giving one another peer feedback.

In the second term, students are urged to start practicing writing collaboratively using the chosen wiki platform. Computer Studies teachers may identify a suitable wiki or other learning management system platform for students, and acquaint themselves and students with the management of its technical requirements. Collaborative writing may be further supported by facilitating students' understanding of the use of a wiki, which allows for synchronous and asynchronous writing and editing to take place online. A wiki allows students to review previous versions of their work and ways of giving constructive comments to their

classmates; the learning experience can be designed to leverage this technical capability. ICT skills, for instance, like understanding the navigation, editing, concurrency, and overwrite functionalities are important foundations in successfully doing so.

Overall, the skills that may be developed through inquiry projects throughout one to two years include reading comprehension, writing, research, presentation, social, communication, and ICT skills.

Table 7.7 Roles of different subject teachers and the school librarian (second year of intervention) proposed by Chu et al. (2012b, p. 84)

Types of teachers	Teachers' Roles
GS teachers	• Guide students in mastering their *subject knowledge* • Facilitate students' development of *research*, *social, communication* and *presentation* skills • Monitor students' progress and give them constructive feedback on their questioning skills, the credibility of their information sources and appropriateness of their presentation materials via assessment of their presentation using PowerPoint or wiki • Reinforce students' ability to reflect by requiring them to do a reflection on wiki upon project completion • Foster students' critical thinking skills via implementation of peer evaluation
Language teachers (Chinese: [C]; English: [E])	• Facilitate the development of students' *reading comprehension* and *writing skills* [C + E] • Give students constructive feedback on their writing via assessment of their various completed written tasks [C + E] • Provide students with passages related to GS topics to consolidate their understanding [E] • Encourage students to practice collaborative writing through group work [C + E]
Computer studies teachers	• Equip students with *IT skills* • Provide training on Chinese input methods[a], Excel, PowerPoint and wiki use • Enhance students' presentation skills through the effective use of presentation software (e.g., PowerPoint and Excel)
The school librarian	• Facilitate students' development of *information literacy skills* (e.g., the ability to evaluate the usefulness of a piece of information) • Provide students with access to a variety of information sources such as a block loan of books from public libraries, news clips and web resources, depending on their needs • Equip students with the knowledge of citing from different types of sources appropriately

[a]Chu et al.'s (2011) study showed that 9- to 10-year-old primary students' IT skills in using Chinese inputting methods such as Jiu Fang or simplified Cangjie were rather weak prior to the intervention. However, their inputting skills improved through training

7.2.2 Teachers' Role in the Second Year of Intervention

Teachers are expected to take up the role as facilitators who mediate students' knowledge development and foster their interest in learning by providing the necessary scaffolding and support. Traditional didactic teaching approaches are replaced by collaborative teaching, through which teachers of different subjects who aim to achieve shared goals co-organize learning activities to facilitate learner progress. Table 7.7 details the roles and responsibilities of each subject teacher in the Chu et al. (2012b) study when implementing GS inquiry projects and English collaborative writing supported by wiki.

It is worthy to note that the teachers' respective roles should be in accordance with their areas of expertise. For example, the GS teacher may wish to focus on students' mastery of subject knowledge as well as monitor their research and relevant ICT skills if this is within the teacher's area of expertise. The school librarian may continue to support students in their search for relevant information from different sources. The language teachers (both Chinese and English) may facilitate the development of students' reading comprehension and writing abilities. The Computer Studies teachers may play a major role in strengthening the technical skills students have cultivated in the first year (e.g., Chinese input methods, Excel, PowerPoint) and train them on other skills needed to manage online wiki platforms.

7.3 Teaching Suggestions for Subject Teachers (Second Year of Intervention)

In the previous section, concrete examples were given to illustrate how inquiry projects can be carried out in a carefully planned and staged manner. In this section, emphasis is placed on the responsibilities and possible teaching schedule of different teachers.

7.3.1 Suggested Teaching Schedule for General Studies (GS) Teachers

GS teachers are encouraged to collaborate with Computer Studies (CS) teachers and exchange information about students' learning progress and project titles with them. The GS teacher may work with the CS teacher to determine the relevant ICT skills students need to learn to carry out their GS group projects effectively.

In the first term, GS teachers may create opportunities for students to employ the strategies of KWL, 5W + 1H and mind-mapping. If they have previously had the experience of constructing mind-maps using pen and paper, they may be urged to try to develop a more sophisticated and comprehensive mind-map using a computer software (e.g., XMind). Groups can be formed, each consisting of students with different kinds and levels of abilities (Cohen and Lotan 2014). Teachers are advised to allow students to freely decide on their own research topics. At this stage, students are expected to perform data collection and analysis independently. Upon completion, they can present their findings and ideas on the chosen wiki platform for comments.

In terms of evaluation, assessment for learning is strongly advocated. Teachers may begin evaluating students' work in progress rather than focusing only on the final reports (Black et al. 2003). Besides quantitative feedback in the form of grades and marks, they can provide constructive formative feedback at different stages of students' work, facilitating ongoing development (William 2003). Peer-evaluation can take place too. Students may be given the chance to evaluate the work of their peers, the process of which is expected to help them better internalize the requirements of the task, the assessment criteria and the expectations of their teachers, enhancing their evaluation as well as editing skills (Topping 2013) (Tables 7.8 and 7.9).

7.3.2 Suggested Teaching Schedule for English Teachers

To promote collaborative writing among primary school students, teachers are encouraged to (1) respond to their work as interested readers (White and Arndt 1991), (2) facilitate their autonomous learning through self- and peer-evaluation, (3) guide them in giving constructive feedback to their peers, (4) maximize whole-group participation and cooperation, and (5) provide them with quality formative feedback in the process as well as evaluate their overall performance in accordance with the stated assessment criteria.

Peer-evaluation and teachers' assessment are complementary in nature. However, it is recommended that teacher feedback come after peer-evaluation to avoid students' reliance on teachers' input. Evaluations may address three key aspects: content, organization and language. Aside from assessing students' work, teachers are also advised to review their peer-evaluations and provide the necessary additional feedback to help them value the importance of giving constructive and specific comments to one another and be reassured of the content of their own comments (Tables 7.10, 7.11, 7.12 and 7.13).

Table 7.8 Suggested teaching schedule for General Studies teachers, extracted from Chu et al. (2012b, p. 87)

Session	Theme	Learning activities
1 2	KWL 5W + 1H Mind-mapping	• Highlight the impact of KWL (What do I *K*now?, What do I *W*ant to know?, What did I *L*earn?) using worksheets. Students can fill in the columns of K and W with respect to the topic they are interested in for their GS project • Present the reading materials to students and guide them in finding out the 5W + 1H (who, when, where, what, why and how). After that, teachers may discuss the answers with students in class • Homework (HW): Students find out 5W + 1H in the assigned readings • Illustrate the idea of drawing mind-maps briefly, and suggest that students incorporate 5W + 1H into their own mind-map • Students create a mind-map on the topic of their GS projects in order to enhance their logical thinking • Teachers read students' mind-maps and give them suggestions on how to improve them for higher quality work • Students bring back the completed KWL worksheets in week 2. Teachers may suggest that students find out the areas they are interested in exploring and encourage them to collect the appropriate resources accordingly
3 4	Information collection	• Students visit libraries, surf the Internet or go to related organizations to collect relevant information • Students utilize the news database and search engines on the web to gather related information • Students upload useful information resources onto the chosen/recommended wiki and share them with other team-mates
5 6	Information analysis	• Students outline the main points of the reading materials, categorize and analyze the resources collected • Students design questionnaires for data collection • Students prepare for the presentation of their data using charts and figures
7 8	Report preparation using wiki	• Students upload the necessary materials onto wiki and prepare for their presentations
9 10	Oral presentations	• Students use wiki to present their projects or PowerPoint as additional visual aids for their presentations. Depending on their learning experiences and abilities, they may be assigned additional tasks, for example, staging a drama or filming a scene to summarize their project findings

Table 7.9 Suggested teaching schedule for language (English) teachers (1st term), adapted from Chu et al. (2012b, pp. 88–89)

Lesson		Title	Focus of teaching and learning activities	
			Tasks for students	The teacher's roles
Week 1	1	Introduction	• Understand the requirements of the collaborative writing task • Learn how to evaluate writing (Optional, depending on students' prior learning experiences) • Search for relevant sources of information at home after Lesson 1 to prepare for the group discussion in Lesson 2	• Explain what collaborative writing is and what skills it entails • Show students how to evaluate one another's work using a genre-based approach (Optional) • Introduce the carefully chosen new theme and the writing topic to students • Go over the schedule and assessment criteria with students • Divide students into groups and give them roles • Explain the roles and responsibilities of each group member to students
	2	Pre-writing	• Brainstorm ideas in relation to given prompts in groups • Participate in discussions and draw a mind-map in groups	• Design a worksheet to facilitate students' information search to prepare for the discussion in class • Facilitate students' group discussion • Give students feedback on their mind-maps in the process
	3	Evaluation I: content	• Conduct peer evaluation on the content of their piece of writing based on the level of interest and relevance of their ideas (Evaluation sheet #1[a])	• Conduct the first assessment on the content of students' work (Evaluation sheet #2[a]) after Lesson 3
Week 2	4	While-writing	• Review peers' comments and read the teacher's feedback • Revise their mind-map based on peers' and the teacher's feedback • Start organizing their ideas in textual form • Begin writing in groups	• Give students whole-class verbal feedback on the content aspects of their mind-maps • Facilitate group discussion and help weaker groups • Ensure collaboration in the revision and writing tasks during group work
	5	Evaluation II: organization	• Continue with their writing • Conduct peer evaluation based on the organization of their ideas (Evaluation sheet #3[a])	• Guide students in providing quality feedback with the help of evaluation templates • Conduct the second teacher's evaluation based on the organization of students' ideas after Lesson 5 (Evaluation sheet #4[a])
	6	Revision of students' work	• Refine their compositions based on peer and teacher feedback on the organization of their work	• Provide additional feedback on the content and organization of students' writing after Lesson 6

(continued)

Table 7.9 (continued)

Lesson		Title	Focus of teaching and learning activities	
			Tasks for students	The teacher's roles
Week 3	7	Revision of students' work	• Polish their composition based on additional feedback from their peers and the teacher	• Facilitate group discussion and encourage equal participation among group members • Give students additional input on vocabulary and grammar if needed • Support weaker groups by giving students more help as they refine their work
	8	Evaluation III: language	• Conduct peer evaluation on language use based on their mastery of grammar and vocabulary (Evaluation sheet #5[a])	• Conduct the third teacher's evaluation on students' language use after Lesson 8 (Evaluation sheet #6[a])
	9	Final revision	• Refine their composition based on peer and teacher feedback on language use • Finalize their piece of writing • Conduct an evaluation on their overall level of enjoyment of and contribution to the writing task (Evaluation sheet #7[a])	• Conduct the fourth teacher's evaluation and scoring of students' final written output after Lesson 9

[a]For templates of evaluation sheets #1–#7, please go to http://web.edu.hku.hk/f/acadstaff/447/teacher%20guide-IPjBL%20P5-v19.pdf

7.3.3 Suggested Teaching Schedule for Computer Studies (CS) Teachers

One key role of CS teachers specified in the projects outlined in Chu et al. (2012) is to strengthen students' ability in using online tools when writing, reviewing, and editing their group project by equipping them with essential wiki-related skills. In the example of focus herein, students are expected to both post their own central wiki content, and have the skill of leaving comments on their peers' written work. In the first term, CS teachers may start by introducing wiki as an online working platform and regularly evaluate their skills in managing it.

Teachers may demonstrate the use of wiki step-by-step, beginning with basic operations such as text editing and commenting. The teaching schedule of the second term may be similar to that of the first term but teachers may wish to devote time to consolidating students' ICT skills. More advanced skills may be

Table 7.10 Suggested teaching schedule for language (English) teachers (2nd term), taken from Chu et al. (2012b, pp. 90–91)

Lesson		Title	Focus of teaching and learning activities	
			Tasks for students	The Teacher's roles
Week 1	1	Introduction	• Understand the requirements of the collaborative writing task • Review the evaluation process • Become familiar with the Google Sites writing platform	• Review what collaborative writing is and how to evaluate each other's/the group's work (optional) • Introduce the new theme and the writing topic to students • Assign each group member a role and entrust them with specific responsibilities • Go over the schedule and the writing platform on Google Sites with students
	HW	Information Search	• Search for relevant sources at home to prepare for the group discussion/tasks in Lesson 2	• Design a worksheet to facilitate students' information search
	2	Pre-Writing	• Brainstorm ideas in relation to the given prompts in groups • Draw a mind-map in groups	• Facilitate students' group discussion • Give students feedback on their mind-maps in the process
	HW	Evaluation I: Content	• Conduct peer evaluation on the content of their work based on the level of interest and relevance of their ideas presented on wiki	• Conduct the first teacher's evaluation (after peer evaluation) focusing on content using wiki
Week 2	3	While-writing (computer lab)	• Review peers' and the teacher's feedback on wiki • Revise their mind-maps following the given feedback • Begin drafting their ideas in textual form in groups on wiki	• Give students whole-class verbal feedback on the content aspects of their mind-maps • Facilitate group discussion as students revise their work on wiki • Ensure collaboration in the revision and writing process during group work • Provide technical support on the use of wiki
	HW	Evaluation II: organization	• Continue with their writing • Conduct peer evaluation based on the organization of their ideas on wiki	• Conduct the second teacher's evaluation on the organization of students' ideas on wiki after Lesson 3
	4	Revision of students' work (computer lab)	• Refine their composition based on peer and teacher feedback on the organization of their writing	• Give students whole-class verbal feedback on the organizational aspects of their writing • Facilitate group discussion and help weaker groups act on the given feedback when revising their work • Ensure collaboration in the writing process • Provide the third set of teacher feedback on the content and organization of students' writing on wiki after Lesson 4

(continued)

Table 7.10 (continued)

Lesson		Title	Focus of teaching and learning activities	
			Tasks for students	The Teacher's roles
Week 3	5	Revision of students' work (computer lab)	• Polish their composition based on additional feedback from the teacher (and peers)	• Facilitate group discussion and encourage even participation among group members • Give students additional input on vocabulary and grammar use if needed • Support weaker groups as students are led to further refine their work
	HW	Evaluation III: language	• Conduct peer evaluation on the language used in their writing on wiki based on their control of grammar and vocabulary	• Conduct the fourth set of teacher's evaluation on language use after Lesson 5
	6	Final revision (computer Lab)	• Continue to enrich their composition based on peer and teacher feedback on their language use • Finalize their piece of writing	
	HW	Final evaluation	• Conduct an evaluation on their overall enjoyment of and contribution to the writing task	• Conduct the final teacher's evaluation and scoring of the students' final written output after Lesson 6

Table 7.11 Suggested teaching schedule for computer studies teachers, adapted from Chu et al. (2012b, p. 92)

Week	Theme	Expected learning outcomes
1	Creating an account	• Assign a username and password to each student and record this information in case students forget their login details. It is suggested that the usernames be easy to remember and consistent among all students. For example, the username of the student in 5A with class number 1 may be set as 2016schoolname5a01
		• Distribute the information containing the username and password to students, after which they can be given help in logging in and creating an account
		• If possible, technicians or teaching assistants may create the accounts for students in advance so teachers mainly assist students with the login
2 3 4	Utilizing wiki	Teach students how to carry out some basic operations on wiki, such as editing and inviting others to join their collaborative platform for knowledge sharing • Google Sites is one of the recommended wiki platforms as it is user-friendly and offers a multilingual platform. The following link provides more details about how to use Google Sites: http://web.edu.hku.hk/f/acadstaff/447/Google-Sites-Notes-for-P5-Students.pdf • PBWorks is another option, free at a basic level with higher levels of paid service. http://www.pbworks.com

Table 7.12 Suggested teaching schedule for school librarians, derived from Chu et al. (2012b, p. 93)

Term	Session	Learning activities	Aims
First Term (optional)	1	Library search, web searching strategies and skills	To review the search strategies and skills used • in the school library • in public libraries (Online public access catalog) • when dealing with search engines • when searching for news articles on WiseNews • when citing references in Chinese, the students' first language
	2		
Second term	1	WiseNews	To teach students how to use WiseNews to search for news and magazine articles in English newspapers
	2	Searching for books	To teach students how to search for English resources • in the school library • in public libraries (OPAC)
	3	Web searching strategies	To teach students how to • search for English resources by using search engines • evaluate information gathered • cite a source in English

Table 7.13 Suggested teaching schedule for Chinese Language teachers, developed based on Chu et al. (2012b, p. 94)

Term	Session	Learning activities	Aims
First term	1	Reading[a] Comprehension Assessment 1 (suggested time limit: 30 min)	To evaluate students' reading and writing abilities
	2	Writing Assessment[b] 1 (suggested time limit: 60 min)	
	3	Literacy training[c] 1	To strengthen students' reading and writing skills
	4	Literacy training 2	
	5	Literacy training 3	
Second term	1	Reading Comprehension Assessment 2 (suggested time limit: 30 min)	To assess students' reading and writing abilities
	2	Writing Assessment 2 (topics related to students' daily life) (suggested time limit: 60 min)	

[a]PIRLS-like (Progress in International Reading Literacy Study) reading tests may be administered to evaluate student reading abilities. PIRLS is an international test which aims to assess fourth graders' (aged 9–10) reading literacy. Until January 2016, close to 50 countries and regions have participated in this international assessment

[b]Students are presented with a passage and required to find the topic sentences of each paragraph and summarize the key ideas of the text in around 100–150 words. A sample of the writing assessment can be found in Appendix 7.1. The assessment rubrics for the writing task are in Appendix 7.2

[c]Literacy training is designed to develop students' reading comprehension and writing abilities. The training exercises are similar to the assessment tasks shown in Appendix 7.1

incorporated, depending on students' readiness, abilities and needs. As students become more familiar with wiki-related skills in the second term, they may be guided in applying the acquired skills in the construction of wiki pages for their GS project. In other implementation examples, for instance in a game design context discussed in Chap. 5, the computer studies teacher or even an outside expert may be called upon, to support students' learning of more advanced computer concepts such as programming code.

7.3.4 Suggested Teaching Schedule for School Librarians

School librarians may begin with a review of the knowledge and skills on keyword search taught in the previous year in the first few weeks of teaching. The timetable (see Table 7.12) suggested for the first term provided below is optional, and may be modified according to students' existing abilities and needs. In the second term, as students become more acquainted with collaborative writing, they may be guided in conducting information searches to identify relevant materials. The focus of IL training may shift to the search and evaluation of materials in the students' second language, in this case English.

7.3.5 Suggested Teaching Schedule for Language (Chinese) Teachers (Optional)

The aim of the training in this area is to consolidate students' reading and writing skills in their first language, in this case Chinese. This is optional, depending on how well the students have mastered the reading and writing skills needed for General Studies inquiry group projects. Teachers may modify the schedule and focus suggested below according to their students' specific learning needs.

7.4 Using Online LMS and Authoring Tools to Support and Scaffold Student Inquiry

Student engagement in inquiry-based learning opportunities may be supported by informational content and resources made available to them on an e-learning platform (or learning management system [LMS]). Salomon et al. (1991) describe

such a resource as a "coordinating representation"—a type of scaffolding support in which an intelligent technology that can "undertake a significant part of the cognitive processing that otherwise would have to be managed by the person" (p. 8) is utilized. Testing a wiki-based LMS with undergraduates, Larusson and Alterman (2009) reported that such environments may be quite useful in facilitating students' project-based work, making it easier for them to work in parallel, multi-task and make "common sense" of the situation and how to proceed with the action, even when they are physically in different locations (p. 375). Wikis may be used as LMSs; other examples include corporate sites like Blackboard and eCollege, as well as free and inexpensive content management services and social media including Google Docs, Google spreadsheets, and Moodle.

The authors of this book have ample experience utilizing wikis, and therefore would like to offer some concrete advice and share their personal opinions in this respect. Nowadays, school administrators, teachers and school librarians are widely experimenting with an array of online e-learning options available, and many cases may be found online via practitioner blogs and trade magazines. In light of these, three practical recommendations on using Web 2.0 are stipulated in this final section of the chapter.

Choosing a wiki. There are a number of wiki applications currently available, and they vary in terms of interface, level of access and cost. Based on the experience of the research team in the Chu et al. (2012b) study, a wiki variant that is easy to manage, requires minimal computer knowledge and has a multilingual interface is preferable. With a multilingual interface, primary school students may choose the language that they are more comfortable with, thereby easing their cognitive and information processing load. This enables them to direct their attention to the content of their work. In addition, a wiki program that can be used at no cost is an advantage for educational purposes, such that budget constraints will not be a hindrance to less privileged school children.

Providing technical support. A range of studies has shown that students generally encounter technical problems in areas such as formatting the content of their writing and uploading materials onto wikis (Chu 2008; Cole 2008; Fung et al. 2011; Law et al. 2011; Woo et al. 2011). For effective utilization of wikis with minimal logistic challenges, teachers may need to organize supplementary classes for students to ensure their familiarity with the use of the online technology. Similarly, teachers may also find it beneficial to acquaint themselves with the technical aspects of using a wiki as a teaching tool.

Addressing parental concerns. When students are using wikis for their projects, there is a possibility that they may be misunderstood by their parents to be visiting undesirable websites or playing online games (Fung et al. 2011; Law et al. 2011;

Yu et al. 2011). It is thus believed to be advisable for schools to run workshops to introduce parents to this new mode of learning, so they are better informed of their children's increased online activities and become cognizant of the potential benefits of wikis on their children's learning processes. These workshops have been seen to enrich parents' knowledge on the operation of wikis and introduce them to ways of assisting in monitoring their children's work (Law et al. 2011). Before the implementation of wikis in the classroom, schools may also find it helpful to notify parents of wiki-related tasks that their children will be performing at home. Finally, it should be emphasized to parents that inquiry PjBL encourages students to be active learners. As such, parental participation in students' work should be minimized to allow room for independent learning to take place and to enable students to experience maximum gains of managing their own learning process.

For more details regarding suggested teaching guidelines, materials and other ideas, please visit http://web.edu.hku.hk/f/acadstaff/447/teacher%20guide-IPjBL%20P5-v19.pdf.

7.5 Conclusion

This chapter has offered pragmatic and pedagogical design recommendations to teachers for implementing inquiry PjBL to facilitate the development of students' twenty-first century skills. Specific guides, models, timetables, particular roles of different teachers as well as the evaluation mechanism in the inquiry design process have been proposed. In order to put PjBL into practice successfully, teachers and students must be ready for the initiative; the expertise of different teachers should be utilized in unison to bring about the best target learning outcomes. With a wide spectrum of online technology available in supporting inquiry PjBL, teachers are advised to carefully choose online teaching and learning tools that are easy to use and to provide students with sufficient training to master the technology. Parental concerns over students' increased use of online activities resulting from inquiry PjBL should be addressed prudently. More independent learning habits from students may be cultivated if parents' support and involvement in the students' project work is strategically reduced. If PjBL is carried out effectively, not only will students produce good projects, but their core competencies will also be broadened and strengthened.

Appendix 7.1 Sample of Reading and Writing Worksheet (Chu et al. 2012b, p. 102)

細心閱讀文章，找出中心句，然後以100-150字寫出篇章大意及感想。
(Instruction: Find the topic sentences of each paragraph and summarize the key ideas of the text with around 100 – 150 words.)

人力車 (Topic: Pulled Rickshaw)

「人力車」，又名「車仔」，「黃包車」和「東洋車」，是一種用人力來牽引拉動的車。

人力車起源於日本，由一美國傳教士發明。自從在1868年左右首度出現，很快便被廣泛應用。由於當時汽車尚未普及，人力車是世界各地十分普遍及重要的運輸工具，尤其是東南亞各地的大城市。

於中國，人力車扮演著十分重要的角色。一位法國商人看準人力車的商業潛力，首先於1873年把人力車引入上海，成立公司經營人力車服務。三十年後，人力車的數目就倍增至多於9000輛，成為當時上海十分流行的交通工具。除了數目增加，人力車的設計亦被多番改良。以它的輪子為例，為了增加行走的穩定性，已由木輪改為橡皮輪，再進化為以後的打氣輪胎。

人力車在1874年「登陸」香港。因為其起源地為日本，香港人都稱它為「東洋車」。人力車的體積小巧，廣東人多叫它做「車仔」。另外，人力車又被稱為「黃包車」，因為車身有一漆布摺篷，座椅又被髹上黃色，每當車夫把摺篷拉下時，車的形狀像個「包子」。當時香港的交通工具以轎子為主，因為人力車較轎子行動快速，而且車費便宜，很快便在香港普及化。全盛時期，香港擁有多約3000輛人力車，手車夫的數量更多達8000多名，可見人力車對香港的公共運輸曾有著舉足輕重的地位。

直至30年代，電車和巴士開始在香港流行，人力車的重要性亦漸漸被削弱。加上香港人的生活水平提高，較富裕的人都紛紛購買私家車代步，最終，香港政府於1968年正式停止發出人力車牌照。時至今天，人力車已變成歷史，曾經是大批人力車聚集地的天星碼頭，現已拆遷，原本停在碼頭附近的人力車也完全消失了。
(The passage above explains the origin and development of pulled rickshaws.)

參考資料： (References)
賢溢（2007）。香港掌故《交通工具—人力車》。大紀元時報。http://hk.epochtimes.com/7/6/1/45690.htm
人力車。維基百科。載入於2012年2月17日。http://zh.wikipedia.org/wiki/%E4%BA%BA%E5%8A%9B%E8%BB%8A

篇章大意及感想（範例）： (Summary and Review - students summarize the ideas of the text and give their own opinions)

「人力車」創始於日本，「登陸」香港後，很快就成為香港一種大眾化的交通工具。人力車曾經是港九的主要交通工具。30年代起，人力車的需求開始走下坡。在1968年，香港政府正式停止發出人力車牌照。今天，九龍尖沙咀天星碼頭附近那幾輛人力車已經完全消失了。
我覺得人力車是一種不人道的交通工具，所以應該被淘汰。
（每段的中心句以底線標示） (Topic sentences are underlined in the passage.)

Appendix 7.2 Assessment Rubrics of Writing Task

評級 (grade)	字數 (word count)	文筆 (language)	內容 (content)
□ 優異 (outstanding)	字數 200 或以上 (200 or above)	文筆流暢 (very fluent)	內容充實, 有創意 (informative and creative)
□ 良好 (good)	字數 150–200 (between 150 and 200)	文筆通順 (fluent)	內容切題 (relevant content)
□ 尚可 (acceptable)	字數 100–150 (between 100 and 150)	文筆一般 (average)	內容尚可 (acceptable)
□ 有待改善 (to be improved)	字數少於 100 (less than 100)	辭不達意 (hard to understand)	內容空洞 (uninformative)

References

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*(1), 1–12.

Arnone, M., Reynolds, R., & Marshall, T. (2009). The effect of early adolescents' psychological needs satisfaction upon their perceived competence in information skills and intrinsic motivation for research. *School Libraries Worldwide, 15*(2), 115–134.

Arnone, M., Small, R., & Reynolds, R. (2010). Supporting inquiry by identifying gaps in student confidence: Development of a measure of perceived competence. *School Libraries Worldwide, 16*(1), 47–60.

Black, P., Harrison, C., Lee, C., Marshall, B., & Wiliam, D. (2003). *Assessment for learning: Putting it into practice*. Maidenhead: Open University Press.

Byrnes, J. (1996). *Cognitive development and learning in instructional contexts*. Boston: Allyn & Bacon.

Cachia, R., Ferrari, A., Ala-Mutka, K., & Punie, Y. (2010). *Creative learning and innovative teaching: Final report on the study on creativity and innovation in education in EU Member States* (No. JRC62370). European Commission: Institute for Prospective and Technological Studies, Joint Research Centre. Retrieved May 8, 2015 from http://ftp.jrc.es/EURdoc/JRC62370.pdf.

Chu, C. B. L., Yeung, A. H. W., & Chu, S. K. W. (2012a). *Assessment of students' information literacy: A case study of a secondary school in Hong Kong*. Paper presented at CITE Research Symposium 2012, The University of Hong Kong, Hong Kong.

Chu, S., Chow, K., Tse, S. K., & Kuhlthau, C. C. (2008). Grade 4 students' development of research skills through inquiry-based learning projects. *School Libraries Worldwide, 14*(1), 10–37.

Chu, S. K. W. (2008). TWiki for knowledge building and management. *Online Information Review, 32*(6), 745–758.

Chu, S. K. W. (2009). Inquiry project-based learning with a partnership of three types of teachers and the school librarian. *Journal of the American Society for Information Science and Technology, 60*(8), 1671–1686.

Chu, S. K. W., Chow, K., & Tse, S. K. (2011). Using collaborative teaching and inquiry project-based learning to help primary school students develop information literacy and information skills. *Library & Information Science Research, 33*, 132–143.

Chu, S. K. W., Tavares, N. J., Chu, D., Ho, S. Y., Chow, K., Siu, F. L. C., & Wong, M. (2012b). *Developing upper primary students' 21st century skills: Inquiry learning through collaborative teaching and Web 2.0 technology*. Hong Kong: Centre for Information Technology in Education, Faculty of Education, The University of Hong Kong.

Cohen, E., & Lotan, R. (2014). *Designing groupwork: Strategies for the heterogeneous classroom* (3rd ed.). New York, NY: Teachers College Press.

Cole, M. (2008). Using Wiki technology to support student engagement: Lessons from the trenches. *Computers & Education, 52*(1), 141–146.

Commander, N. E., & Smith, B. D. (1996). Learning logs: A tool for cognitive monitoring. *Journal of Adolescent & Adult Literacy, 39*(6), 446–453.

Crawford, A., Saul, W. E., Mathews, S., & Makinster, J. (2005). *Teaching and learning strategies for the thinking classroom*. New York: The International Debate Education Association.

Education Bureau. (2014). *Basic Education Curriculum Guide (P1-6)* 2014. Hong Kong. Retrieved Jan 10, 2016 from http://www.edb.gov.hk/attachment/en/curriculum-development/doc-reports/guide-basic-edu-curriculum/BECG_2014_en.pdf

Ferrari, A., Cachia, R., & Punie, Y. (2009). Innovation and creativity in education and training in the EU Member States: Fostering creative learning and supporting innovative teaching. *JRC Technical Note*, *52374*. Retrieved May 8, 2015 from http://ftp.jrc.es/EURdoc/JRC52374_TN.pdf

Fung, K. Y., Chu, S. K. W., Tavares, N., Ho, G., & Kwan, K. (2011). Using google sites in english collaborative writing. *Paper presented at CITE Research Symposium 2011*, The University of Hong Kong, Hong Kong.

Gibson, H. L., & Chase, C. (2002). Longitudinal impact of an inquiry-based science program on middle school students' attitudes toward science. *Science Education, 86*(5), 693–705.

Gordon, C. (2006). A study of a three-dimensional action research model for school library programs. *School Library Media Research*. Retrieved May 8, 2015 from http://www.ala.org/aasl/sites/ala.org.aasl/files/content/aaslpubsandjournals/slr/vol9/SLMR_ThreeDimensionalActionResearch_V9.pdf

Harada, V. H., Kirio, C. H., & Yamamoto, S. H. (2008). *Collaborating for project-based learning in grades 9-12*. Worthington, Phio: Linworth Publishing.

Harada, V. H., & Yoshina, J. M. (2004). *Inquiry learning through librarian-teacher partnerships*. Worthington, Ohio: Linworth Publishing.

Heick, T. (2013). *An Inquiry Framework: 5 Levels of Student Ownership* (TeachThought) Retrieved May 8, 2015 from: http://www.teachthought.com/learning/inquiry-framework-levels-student-ownership/

Kishbaugh, T. L., Cessna, S., Horst, S. J., Leaman, L., Flanagan, T., Neufeld, D. G., et al. (2012). Measuring beyond content: A rubric bank for assessing skills in authentic research assignments in the sciences. *Chemistry Education Research and Practice, 13*(3), 268–276.

Kuhlthau, C. C., & Maniotes, L. K. (2010). Building guided inquiry teams for 21st-century learners. *School Library Monthly, 26*(5), 18–21.

Kuhlthau, C. C., Maniotes, L. K., & Caspari, A. K. (2007). *Guided Inquiry—Learning in the 21st Century*. Westport, CT: Libraries Unlimited.

Kuhlthau, C. C., Maniotes, L. K., & Caspari, A. K. (2012). *Guided Inquiry Design—A framework for inquiry in your school*. Santa Barbara, CA: Libraries Unlimited.

Larusson, J. A. & Alterman, R. (2009). Wikis to support the "collaborative" part of collaborative learning. *Computer-Supported Collaborative Learning, 4*, 371–402.

Law, H. C., Chu, S. K. W., Siu F., Pun, B. & Lei, H. (2011). Challenges of using google sites in education and how students perceive using it. *Paper presented at CITE Research Symposium 2011*, The University of Hong Kong, Hong Kong

Lee, D., & Gavine, D. (2003). Goal-setting and self-assessment in Year 7 students. *Educational Research, 45*(1), 49–59.

Lombardi, M. M. (2007). Authentic learning for the 21st century: An overview. *Educause learning initiative, 1*(2007), 1–12.

McLoughlin, C., & Oliver, R. (2000). Designing learning environments for cultural inclusivity: A case study of indigenous online learning at tertiary level. *Australian Journal of Educational Technology, 16*(1), 58–72.

McMullan, M., Endacott, R., Gray, M. A., Jasper, M., Miller, C. M., Scholes, J., et al. (2003). Portfolios and assessment of competence: A review of the literature. *Journal of Advanced Nursing, 41*(3), 283–294.

Montiel-Overall, P. (2005). Toward a Theory of Collaboration for Teachers and Librarians. *School Library Media Research.* Retrieved May 8, 2015 from http://www.ala.org/aasl/sites/ala.org.aasl/files/content/aaslpubsandjournals/slr/vol8/SLMR_TheoryofCollaboration_V8.pdf

Montiel-Overall, P. (2008). Teacher and librarian collaboration: A qualitative study. *Library & Information Science Research, 30*(2), 145–155.

Mullis, I. V. S., Martin, M. O., Kennedy, A. M., Trong, K. L., & Sainsbury, M. (Eds.). (2009). *PIRILS 2011 assessment framework*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

Paechter, C. (1995). *Crossing subject boundaries: The micropolitics of curriculum innovation*. London: HMSO.

Salomon, G., Perkins, D. N., & Globerson, T. (1991). Partners in cognition: Extending human intelligence with intelligent technologies. *Educational Researcher, 20*(3), 2–9.

Learning, Schwab. (2003). Collaboratively speaking: A study on effective ways to teach children with learning differences in the general education classroom. *The Special Edge, 16*(3), 15–20.

Sousa, D. A. (2011). *How the brain learns*. California: Corwin Press.

Thousand, J. S., Villa, R. A., & Nevin, A. I. (2006). The many faces of collaborative planning and teaching. *Theory into practice, 45*(3), 239–248.

Todd, R. J. (2012). School libraries as pedagogical centers. *SCAN*. Retrieved May 26, 2014 from http://scan.realviewdigital.com/default.aspx?iid=65737#folio=27

Tomlinson, C. A., Brighton, C., Hertberg, H., Callahan, C. M., Moon, T. R., Brimijoin, K., et al. (2003). Differentiating instruction in response to student readiness, interest, and learning profile in academically diverse classrooms: A review of literature. *Journal for the Education of the Gifted, 27*(2), 119–145.

Topping, K. J. (2013). Peers as a source of formative and summative assessment. In J. H. McMillan (Ed.), *Handbook of research on classroom assessment* (pp. 395–412). Los Angeles: Sage.

Vygotsky, L. (1978). Interaction between learning and development. *Readings on the development of children, 23*(3), 34–41.

Walsh, A. (2009). Information literacy assessment: Where do we start? *Journal of Librarianship and Information Science, 41*(1), 19–28.

White, R., & Arndt, V. (1991). *Process writing*. London: Longman.

William, J. G. (2003). Providing feedback on ESL students' written assignments. *The Internet TESL Journal, 9*(10). Retrieved May 8, 2015 from http://iteslj.org/Techniques/Williams-Feedback.html.

Wolfe, P. (2001). *Brain matters: Translating research into classroom practice*. Alexandria, VA: ASCD.

Woo, M., Chu, S., Ho, A., & Li, X. X. (2011). Using a Wiki to scaffold primary school students' collaborative writing. *Journal of Educational Technology & Society, 14*(1), 43–54.

Yu, C. T., Fong, C. S., Kwok, W. K., Law, S. M., Chu, S. K. W., & Ip, I. (2011). Using google sites in collaborative inquiry projects in general studies. *Paper presented at CITE Research Symposium 2011*, The University of Hong Kong, Hong Kong.

Zohrabi, M., Sabouri, H., & Behroozian, R. (2012). An assessment of strengths and weaknesses of Iranian first year high school English coursebook using evaluation checklist. *English Language and Literature Studies, 2*(2), 88–89.

Chapter 8
Assessment Instruments for Twenty-First Century Skills

It has been established in previous chapters that learning and teaching has significantly evolved over the past few decades, toward a greater emphasis on twenty-first century skills in the school curriculum. Twenty-first century skills are incorporated into national educational standards in many countries; assessments, however, have been less emphasized as integral components of these new models (Hilton 2010). Inquiry- and project-based learning interventions involving research as well as technology require compatible methods of assessment to support learners' progress and development (Cachia et al. 2010). This chapter begins with an overview of previous literature on assessment of twenty-first century skills, then discusses the use of assessments in a variety of research studies conducted by the authors, and proposes an evidence-based approach for assessing different aspects of twenty-first century skills. Education practitioners and researchers should bear in mind that some of the twenty-first century skills such as life and career skills are not always easily measurable in quantitative terms. The chapter therefore focuses on skills that could be evaluated in relatively more concrete ways during an assessment.

8.1 Overview of Assessment Instruments for Twenty-First Century Skills

The adapted P21 framework of twenty-first century skills in Chap. 1 outlines three skill sets containing a total of twelve components that learners are said to need to possess. The skill sets are: learning and innovation, digital literacies, and life and career skills. The conceptual framework of the relationship between twenty-first century skills and teaching strategies (Chu et al. 2012c) shows assessment as a way of reflecting learning outcomes. Outcomes can be assessed in terms of product outcomes based on the grades of learners' final output of their learning activities, and in terms of process outcomes, by evaluating their learning in the process and

S.K.W. Chu et al., *21st Century Skills Development Through Inquiry-Based Learning*, DOI 10.1007/978-981-10-2481-8_8

interactions while completing tasks. Researchers and education practitioners make use of various tools to evaluate learning outcomes in these two aspects.

The P21 report on assessment of twenty-first century skills (Honey et al. 2005) outlines the objectives that an ideal form of assessment should fulfill. Assessments should:

- Measure learners' knowledge, application and learning of twenty-first century skills, and identify where intervention is required.
- Be applicable across a wide range of instructional programs.
- Allow learners to demonstrate their proficiency in twenty-first century skills to educational institutions and prospective employers (Honey et al. 2005).

The report acknowledges that diverse assessment tools are needed as a single assessment instrument cannot meet all these objectives. In fact, assessment methods need to go beyond traditional standardized tests (Redecker and Johannessen 2013) and various tools have been designed to support such methods. The convenience of having a wider range of assessment tools brings forth the challenge of choosing the most suitable ones. Designers of assessment tools should take into consideration the ease of administering the test, if a test is used, and how truly the test reflects learners' skills (Walsh 2009).

Table 8.1 provides a snapshot of ways in which twenty-first century skills are currently being assessed by researchers around the world. Research projects are organized according to the dimension of the twenty-first century skills they assess. The assessment method employed in each project is summarized, along with relevant scholarly citations.

8.2 Case Studies on Assessing Twenty-First Century Skills

The following section captures the authors' experience in assessing students' twenty-first century skills. Five knowledge outcome dimensions are covered: *reading literacy*, *collaboration*, *information literacy*, *information technology literacy,* and *media literacy*.

8.2.1 Assessing Reading Literacy Through Gamification

Reading is a vital skill for life-long learning and the development of twenty-first century skills. Strong readers have been shown to demonstrate more advanced critical thinking (Hawkins 2012) and there is a positive and significant relationship between one's reading ability and information literacy (Sayed 1998; Chu 2012). Both the promotion of reading and assessment of reading progress have been found to be important to the development of students' reading abilities (Afflerbach 2011; Wu et al. 2014; Chan et al. 2015).

Table 8.1 Methods to assess twenty-first century skills

	Assessment method	Reference
Learning and innovation		
Core subjects	Programme for International Student Assessment (PISA): Multiple choice questions and open-ended questions on reading, mathematics and scientific literacy	OECD (2012)
	Progress in International Reading Literacy Test (PIRLS): Multiple choice questions and constructed response items, focusing on the reading purpose, process, behaviour and attitudes	Mullis et al. (2009)
	Reading Battle: An online e-quiz bank to promote and assess students' reading interest and comprehension ability	Wu et al. (2014)
Critical thinking and problem solving	Sternberg Triarchic Abilities Test (STAT): Multiple choice questions in verbal, quantitative and figural forms	Sternberg (2006)
Communication and collaboration	Ongoing observation of group work via a web-based collaboration tool	Chu et al. (2012b), Reynolds (2010)
	Self-assessment of perceived social skills using questionnaires	Notari and Baumgartner (2010)
	Online portfolio assessment in which learners report and reflect on their project-based assignments, group activities and workplace projects	Koenig (2011)
Creativity and innovation	Torrance Test: written and drawn answers, yielding subject scores for each characteristic assessed, and a cumulative score for each individual	Torrance (2000)
Digital literacies		
Information literacy	Test made up of multiple choice questions, adapted from TRAILS	Chu (2012), Chu et al. (2012a)
	Mixed-method design involving tests, surveys, interviews and documentary analysis	Chu et al. (2012a)
	Direct assessment of researched term papers	Scharf et al. (2007)
	Diagnostic inventory of students' perceived competence and motivation towards inquiry and research	Arnone et al. (2009, 2010)
Media literacy	Questionnaire on media awareness and media use pattern, consisting of open-ended questions and statement evaluation of responses to the statements using the Likert scale	Chu et al. (2010)
	Assessing learners' critical reading, listening and writing skills after receiving media literacy instruction	Hobbs and Frost (2003)

(continued)

Table 8.1 (continued)

	Assessment method	Reference
Information technology and communication literacy	Questionnaires and interviews asking about perceptions of learning progress	Chu et al. (2008, 2011b), Chu (2009)
	Content and IT literacy knowledge outcomes, as measured using content analysis methods to evaluate learners' final digital product creation, via application of a reliable evaluative coding scheme	Reynolds (2010), Reynolds and Harel Caperton (2009)
	Test tools assessing knowledge on computer hardware and software operation and information processing	Cha et al. (2011)
	Performance-based assessment in a virtual school or work situation	Claro et al. (2012)

Traditionally, reading assessments include short quizzes, reading comprehension exercises or book reports. However, such assessments may exert pressure on readers, and it can be time-consuming for teachers to read, mark and provide feedback to students on their work. With the aim of cultivating reading and comprehension skills among students as well as facilitating effective monitoring and evaluation of student learning, Wu et al. (2014) devised a motivate-scaffold-monitor framework to gamify students' reading experience and provide a quick and easy platform for teachers to evaluate and monitor students' reading comprehension level through a program called "Reading Battle." Figure 8.1 below presents the program framework:

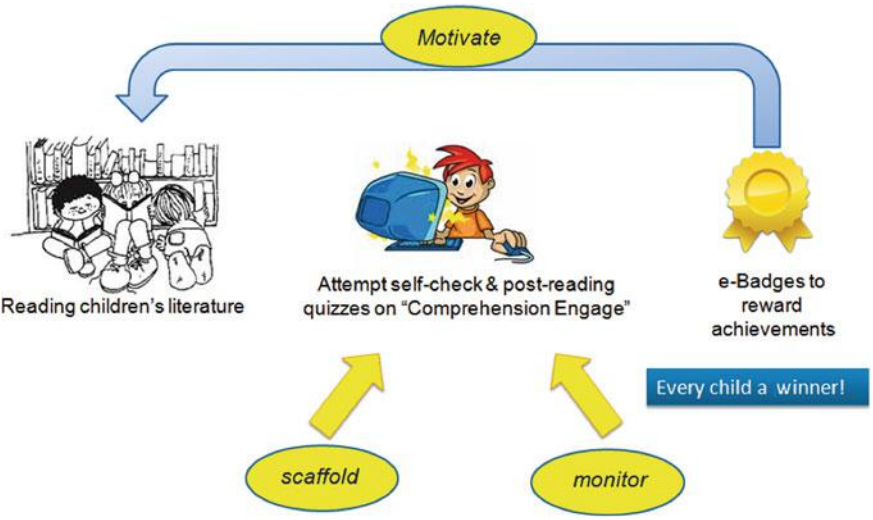

Fig. 8.1 The motivate-scaffold-monitor framework in the project (Wu et al. 2014)

Reading Battle is an online e-quiz bank that houses more than 13,500 questions written based on 450 books (W. Wu, personal communication, April 8, 2015). Users can access the quizzes via a search using the title, author, book ID or ISBN, or select from the archive of books sorted into different genres. Once a book is chosen, users enter the test interface. Each test consists of 10 multiple choice questions randomly drawn from a pool of 30 questions. With 180 books picked by the project team and an additional 270 school-based titles from each participating school, student-users have the flexibility of selecting books they like to read and browse the archive for further reading suggestions.

Questions in the quiz focus on the 4 processes of comprehension adapted from the PIRLS 2011 Assessment Framework: information retrieval, making inferences, interpretation and integration of ideas, and evaluation (Mullis et al. 2009). These four processes match the Bloom's Taxonomy of learning domains, for example, making inferences relates the domain of understanding, whereas interpreting and integrating ideas falls into the domain of applying and analyzing (Bloom et al. 1956). Aided by prompts and hints, students are guided in finding the right answer after an initial failure. For particularly challenging questions, an instant explanation is given for the correct answer. The system is designed to interact with users and provide immediate feedback. Upon completion of the test, the total score is shown. Participants earn points for every correct answer. E-badges of different levels are awarded as recognition of their achievement and encouragement to challenge them to reach a higher level and/or compete with others in the leaderboard. These gamified applications have the advantage of providing participants with a sense of challenge and curiosity (Deterding et al. 2011) as well as enhancing their experience and engagement (Domínguez et al. 2013). Logging in with a teacher account enables teachers to view their students' test scores and participation rate, thereby allowing them to evaluate the progress of students' reading abilities and offer support to and/or guide them toward the correct reading practices as appropriate.

Reading Battle was piloted in 9 primary schools in Hong Kong in 2014 involving student participants from primary 3 to 5 (aged 7–11). Students' reading abilities were benchmarked prior to the implementation of the program. Post-tests of individual students were administered 5 months after the implementation. Preliminary findings have shown that students who actively took part in Reading Battle achieved higher reading test scores in the post-test compared to those in the same age group who seldom or never joined Reading Battle. They also improved in their Chinese and English reading and writing skills, with over 70 % citing the Reading Battle as a reason behind (Lu et al. 2016). In the case of one of the participant, the improvement was as significant as a jump from 10 marks to 90 marks out of 100, in the English and General Studies subjects. Impact of Reading Battle is not limited to academic performance—students' character developed as they read stories about essential virtues such as honesty, caring for others, and other interpersonal skills (Lu et al. 2016).

In addition to students describing Reading Battle as "appealing," "exciting," and "fun," teachers was pleased to observe their students' growing motivation and confidence to read. Extrinsic motivation such as the e-badge system as well as

students' intrinsic motivation to acquire more knowledge has also challenged students to do more reading and complete more quizzes (Chan et al. 2015; Lu et al. 2016). In one school, students were so eager to join Reading Battle that a much higher book borrowing rate was recorded, with the school library reporting an average of more than a hundred books loaned out per week. Interviews with parents also revealed encouraging findings. One parent exclaimed in an interview that her son, a primary 4 student, after reading books of difficulty levels 1–4, could write compositions with better organization and had since then performed better in the school's writing assessments. Information gathered also showed that a primary 3 boy could read on his own rather than being read to by his mother which used to be the case. A primary 4 girl, who could not find the Reading Battle books she wanted to read from the school library nor afford to buy the books she liked, was found spending hours in commercial bookstores, trying to read and remember as much book content as she could so that she could be ready for the challenge in Reading Battle. Another primary 4 boy, who did not have a computer at home, was seen investing as much time as he could in the school library doing quizzes from Reading Battle. All four students performed very well in Reading Battle. The students' performance corroborates with the social cognitive theory, which suggests that participation in educational interventions in which students have a chance to "experience success" increases their self-efficacy in educational knowledge domains (e.g., Luzzo et al. 1999).

The rapid advancement of computer facilities and mobile technology nowadays has opened up new doors not only for teaching and learning (Chu et al. 2015; Kwan et al. 2015; Hew et al. in press), but also for student assessment (López 2010). Reading Battle, a computer-graded e-quiz bank, can save a considerable amount of teachers' time evaluating students' comprehension abilities and grading their reading reports. Teachers can also trace students' reading skills development with ease while students enjoy the gamified reading experience, thereby fostering the engagement of both and boosting their motivation during the learning and assessment process.

8.2.2 Assessing Collaboration

Two case studies on assessment of peer collaboration are discussed in this section. The first study (Chu et al. 2012b) was carried out in Hong Kong, focusing on assessing how secondary school students worked together to complete a wiki-based writing project. The second study (Notari and Baumgartner 2010) involved Swiss University students in a group project, and evaluated the degree of their collaboration by the students' self-assessment of their social skills. Although assessment of students in higher education is not the focus of this chapter, for the benefit of researchers and education practitioners, the study is included as the assessment method adopted is believed to be transferable to primary and secondary school contexts.

8.2.2.1 Assessing Collaboration in Wiki-Based Collaborative Writing

Assessing collaboration has always been deemed a particularly challenging task for teachers, due to the inherent difficulty in obtaining information about individual students' contributions. For instance, one or two members in a group may take up a large proportion of work during the process without the teacher noticing. The use of wikis nonetheless provides teachers with access to an imprint of their students' collaboration process. A wiki offers users a platform to directly create and edit the content of one or more webpages through web browsers (Leuf and Cunningham 2001). It can show, to a certain extent, users' level of collaboration and how they work together. The following section explores how wikis support the evaluation of student collaboration. Chu et al. (2012b) discussed how this was assessed through observing students' work on wikis using data generated by wiki pages, while Chu et al. (2011b) shed light on affordances that wikis have for assessing collaboration from the teacher's perspective.

The aim of Chu et al.'s (2012b) study was to investigate the patterns of activities of twenty-five secondary one students (aged 12–13) in their inquiry-based project, their level and frequency of participation, as well as the distribution of work and the degree of collaboration among group members. Assessment began with extracting data, both qualitative and quantitative, from the students' wiki-based group reports covering topics on media, education, religion, sports, art, information, communication technology, etc. Students in a class were divided into five groups and their contribution was categorized as either content input in the compilation of the report or comments posted on wikis. The built-in functions of Google Sites enabled both types of data to be recorded. Input from individual students was made visible using the revision history function, which allowed direct access to all previous versions of a page. Details of each change were logged, including the name of the student who made the change, the date and time of the change, and the specific change in the content. Quantification of data revealed how much and how often students made a contribution to the content, and enabled categorization of changes to identify the types of action commonly performed. The categorization of changes was based on a modified version of the action taxonomy developed by Meishar-Tal and Gorsky (2010). The taxonomy classifies students' actions on the wiki content by, for example, adding, deleting and moving texts, and editing of format and grammar.

Comments made by students, the second type of contribution on wiki, were retrieved from the comprehensive records of messages and replies. By analyzing the records, researchers could understand the degree of collaboration among the students. The comments were organized using an adapted content analysis coding scheme following the work of Judd et al. (2010). Their scheme placed the comments into six nonexclusive categories: content, form, work, individual, group, and reply.

Drawing on the findings of Chu et al.'s (2012b) study, uneven work distribution was observed, with considerable disparity among group members in terms of the amount of actions each member performed and the proportion of work done. Generally, two to three members out of 5–6 in a group took charge of most of the

actions and contributed to a large part of the writing up of the project. The unequal share was, as the researchers explained, a result of students' collaborative writing strategy. The report-writing task was split into discrete units and group members were assigned to work on separate units. Students might also have participated in pre-writing work like questionnaires, interviews and presentations but this was not recorded.

Students displayed a certain degree of collaboration, as evidenced by the comments they left on their wikis. Comments concerning content and those addressing the whole group made up more than half of all the comments, with a similar distribution pattern across groups. Both types of comments indicated engagement in online communication and exchange of ideas. Students, however, might not have communicated exclusively using the commenting function, limiting the extent to which the comments painted a complete picture of their collaboration. Their assessed level of collaboration shown on wikis was thus treated with caution.

Interviews with teachers in Chu et al. (2011a) revealed that teachers were generally satisfied with Google Sites (a wiki variant) promoting collaboration. Using the function "history review" and "version comparison," teachers could track changes made by each individual throughout the project. Teachers were then able to grade students' performances fairly and objectively after examining their personal contributions. The tracking function also enabled teachers to identify high and low achievers, and in turn offer support to the less capable students. In addition, teachers noted that the commenting function allowed them to leave comments without restriction of time, space and even text, since videos, photos and quotes can be embedded in the comments. Teachers found that guidance could easily be given to help students understand relevant concepts and amend their work in progress, thereby lending itself to assessment for learning.

In the light of the above study, when using wiki-based platforms for collaborative group projects, teachers are advised to trace the edit histories in order to identify and assess individual students' contribution. Contributions to wiki content may take the form of posts and comments, which can be further coded as content/meaning related, surface level, and management-focused/other contributions (Woo et al. 2013). Examining these posts and comments during project execution helps the teacher decide on the type of support required and offer the right form of intervention by leaving comments on the wiki page. Tracing such edits after the project further makes it possible for the teacher to collect information on students' collaboration process and evaluate their performances accordingly.

8.2.2.2 Assessing Collaboration Through Self-assessment of Social Skills

This section documents a project led by one of the book's authors investigating how social skills configuration within groups of university students collaborating on projects affect their communication, satisfaction with group performance, and

quality of collaboration (Notari and Baumgartner 2010; Notari et al. 2014). The social skills analyzed are cooperation/compromising, prosocial behavior/openness, social initiative, leadership, and assertiveness. Fifty-nine students took part in the study. They freely formed groups of 2–3, and the groups were described as comprising a combination of students with heterogeneous or homogeneous abilities, as well as high and low levels of various social skills. A questionnaire was administered both at the beginning and end of the project. The pre-questionnaire consisted of 16 statements that assess individual students' social skills including exchange orientation, empathy, initiative, leadership, and assertiveness, which students were required to rate on a scale of 1–4 (totally disagree: 1—totally agree: 4). In the post-questionnaire, students evaluated their own level of satisfaction and quality of cooperation using the same scale as in the pre-questionnaire. The questionnaire contained six statements, as shown below:

1. I am satisfied with the level of team work achieved.
2. The group worked together in an efficient way.
3. The responsibilities were clearly distributed among the group members.
4. There was a group leader.
5. We got along well within the group.
6. We supported and/or complemented one another well in the group.

Data analysis showed that examination of social skills on a group level yielded more meaningful findings than that on an individual level. A homogeneous and/or high-level of social skill configuration in a group tended to be more conductive to effective collaboration than groups with heterogeneous and/or low-level social skills. This relationship was especially significant for social skills that focused on communal goals such as compromising, in which students perceived a higher degree of group efficiency and clearer division of labor. The same correlation was observed in prosocial behavior/openness, where heterogeneity decreased reciprocity and equity among group-mates, leading to dissatisfaction with performance, and a felt lack of efficiency in collaboration and division of responsibilities.

Given the aforementioned findings, teachers are encouraged to teach students relevant social skills before engaging them in collaborative group work. A good starting point would be to strengthen their ability to cooperate and come to a compromise, foster prosocial behaviors, and boost their leadership skills. Compromising can be achieved by a clear share of responsibilities and identifying specific roles of individuals within the group. Teachers should, however, be aware that a high level of compromise may diminish the group's permissibility for members to put forward their own ideas (Zurita et al. 2005). In order to promote prosocial behavior, it is vital that students respect the equity and reciprocity among group members (Hatfield et al. 1978) so that organizational agreements may be reached more efficiently. As for leadership, teachers may create room for students to take charge of tasks, since it was shown from the project that a higher average leadership level in the group results in more efficient collaboration.

8.2.3 *Assessing Information Literacy (IL) Using IL Assessment Tools*

Two case studies assessing IL are presented in this section, one targeting upper primary students (aged 9–11) (Chu 2012) and the other junior secondary students (aged 12–15) (Chu et al. 2012a).

IL instruction is in great demand in Hong Kong. In secondary schools, inquiry project-based learning has been integrated into the formal curriculum, and Liberal Studies is one of the core subjects (Curriculum Development Council [CDC] 2000). In primary schools, information literacy education is spaced out in two stages: primary one to three for Stage I (aged 6–8), and primary four to six for Stage II (aged 9–11). Guidelines for each stage are provided on the skill types that students are expected to acquire, in terms of learning targets, knowledge, skills, and attitude (Education and Manpower Bureau [EMB] 2005). Nevertheless, no standardized territory-wide assessment for information literacy exists, limiting educators from assessing students' IL abilities. Both studies featured in this section evaluate IL of students of different levels, aiming to provide empirical evidence for further research on ways to enhance students' IL competence.

8.2.3.1 A Case Study of Primary Five Students

The study conducted by Chu (2012) made use of the Tool for Real-time Assessment of Information Literacy Skills (TRAILS) to evaluate the IL of 199 primary five students (aged 10–11) from four schools in Hong Kong. The IL assessment tool consisted of 14 items (see Appendix 8.1) which matches well with the IL framework set by the Hong Kong government. As such, the IL assessment instrument has the potential to be generally applicable to Hong Kong primary school students. Modifications to the assessment were made to suit students' comprehension ability and to place questions in a more familiar context, since TRAILS was originally designed for American students. The contextualized test was then translated into Chinese, the students' first language, for their ease of understanding, but specific English terms were retained to avoid misinterpretation. All questions were close-ended, with two to four options each. Each correct answer was worth 1 point, and the maximum score was 14. Students' responses in the IL assessment were collected through SurveyMonkey, an online survey tool administered by students' IT teacher during regular class hours.

With the descriptive statistics of the participants' test scores calculated, the results were analyzed. The mean correct number of questions was 8.12 (SD = 2.56). No significant difference in mean score was noted among the four schools. The assessment questions were then categorized according to relevant American Association of School Librarians (AASL) and Association for Educational

Communications and Technology (AECT) IL standards. Seven questions correspond to standard one, the ability to access information efficiently and effectively, and five questions to standard two, the ability to evaluate information critically and competently. The overall results showed that students possessed some but inadequate IL competency. The mean score for standard one and two were 4.63 and 3.29 respectively. The percentage of correctness for each answer was compared to the expected percentage based solely on guessing, and the sufficiently higher observed percentages indicated that students, in most cases, performed better than wild guessing. Still, they could only correctly answer half of the questions related to each standard, and this suggested that there was much room for improvement and that a systematic IL curriculum was urgently needed (Crawford and Irving 2013; Sandars 2012).

8.2.3.2 A Case Study of Secondary One Students

In the study carried out by Chu et al. (2012a), the IL level of 176 secondary one students (aged 12–13) was assessed. A mixed-method research design was adopted, combining quantitative and qualitative research tools such as surveys, interviews, documentary analysis of students' group projects, and a test made up of multiple choice questions. First, in order to evaluate students' IL skills, a test comprising 15 multiple choice questions set according to TRAILS was administered. Their IL skills concerning proper and ethical use of information sources were analyzed through examination of their group projects. Before further investigation by the researchers, an online free plagiarism checker was employed to look into whether students' citations resembled any form of plagiarism. Interviews were then conducted to better capture students' and teachers' knowledge and attitude toward IL in their completion of the group project.

Based on the test results, content analysis of the interviews and the projects, students' learning outcomes were mapped using indicators provided by the IL framework (EMB 2005). The framework categorizes learning outcomes into four dimensions: cognitive, metacognitive, affective, and socio-cultural. The number of indicators on a particular level shows students' performance in that dimension. The secondary one students were found to possess IL skills primarily at Level II, the stage of primary four to six, but they demonstrated progress in the cognitive dimension. A breakdown of students' performance in the IL multiple choice test revealed their strengths and weaknesses. The test results shed light on students' ability to identify potential sources, but they were weak in using information sources in a responsible and ethical manner.

According to the findings, the researchers were able to denote aspects of students' IL that required enhancement. Overall, their poor understanding of plagiarism called for more education and training to raise their awareness of and knowledge on the issue.

8.2.4 *Assessing IL and IT Literacy by Perceived Learning Progress*

Apart from assessing IL and IT literacy through particular assessment tools as referred to in Sect. 8.2.3, IL and IT literacy is sometimes assessed by students,' parents,' and teachers' perceptions of learning progress. In the following section, a study which illustrates the role of perception in evaluating one's IL and IT skills is introduced. Although assessment on the basis of perception may not be the most direct method of reflecting students' competency, it contributes greatly to portraying their strengths and weaknesses, and this helps educators locate areas in need of intervention, support, and improvement.

8.2.4.1 Assessing Student Development of IL and IT Literacy Through Student and Parent Perspectives

Primary four (aged 9–10) students from a school in Hong Kong joined a project examining the effect of combining collaborative teaching and inquiry project-based learning (Chu et al. 2008; Chu 2009). Over a six-month period, students carried out two General Studies projects on two different topics, in which they were required to perform various IL and IT skills-oriented tasks. Teachers of three subjects (General Studies, Chinese, and IT) and school librarians assisted in the process and provided guidance to students when needs arose. Upon completion of the projects, students and parents were invited to articulate the difficulties they encountered and the students' improvement in their IL and IT skills.

Telephone interviews with parents were conducted. Parents were told to rate the difficulty of the project on a 5-point ordinal scale, in which 1 meant very difficult and 5 very easy. They were then asked about their child's improvement in aspects such as their ability to locate information, and competency in computer-related skills like the use of PowerPoint and Chinese word processing. Students were asked the same questions in a questionnaire administered in class by their teachers. In-depth information regarding teachers' perception of the projects was obtained through interviews.

Results suggested that both students and parents considered the tasks easy, while teachers had a relatively neutral stance, rating the tasks in the middle of the scale. The difference in their ratings were, however, not significant. In particular, conducting online searches was one of the difficulties more commonly reported by students, as stressed by General Studies and Chinese language teachers. The results showed that the level of difficulty was linked to perceived improvements in certain dimensions of learning. Participants who gave higher ratings on the ease of the project rated advancement in reading and writing ability, IT skills, and presentation skills more positively, implying that improvement may be induced by students' perceptions that the project was not too difficult.

Students' perception of their IL and IT skill gains was also checked in a slightly different way (Chu et al. 2011c). Using questionnaires, students were required to rate their familiarity with various information sources, searching skills, and IT skills before and after participating in the project (see Appendix 8.2). Dependent t-tests were used to compare their ratings of familiarity in each aspect. Increased familiarity in a certain aspect was found to correlate with improvement in the corresponding skills.

After the project, students considered themselves more familiar with all the dimensions of IL and IT skills in focus. It was also discovered that as the accessibility of searching tools and computer software increased, greater improvement was noted in students' familiarity with the use of the corresponding tools/information services. For instance, students did not have free access to Wisenews (a news database) in the past, resulting in a substantially lower familiarity prior to intervention and the biggest improvement in the IL domain.

8.2.4.2 Learning Analytics Measures of Student in Progress Digital Behaviors

Around the world people are now taking pride in an increasing availability of e-learning management systems and other digital environments provided by educational technology developers and entrepreneurs, and in parallel, more widespread adoption of such platforms by educators, school districts, and other organizations aiming to educate learners. With the development and deployment of these new platforms comes a growing proliferation of digital trace log data (educational "big data") generated by the systems themselves that produce an imprint of learner behaviors and actions in the environment. Many inter-disciplinary parties are pursuing the use of "learning analytics" (Siemens and Baker 2012) to aid the cultivation of intelligent digital settings that aggregate, measure, and report upon user actions, and that are moving toward offering predictive and diagnostic evaluative models and agents that can support the learner—in some of which the system itself scaffolds the learning intelligently, while also providing teachers with diagnostic and moderation tools (Wu et al. 2014).

The field of learning analytics (LA) addresses the collection and analysis of such data about learners and their engagement in such environments. The field also involves the design of new digital evaluative systems that are responsive to user actions. The community now has its own conference and journal to further drive this agenda item (LAK conference; Journal of Learning Analytics). Cooper (2012) identifies several research and organizational communities out of which LA approaches are derived, including

- Statistics
- Business intelligence
- Web analytics
- Operational research

- Data mining and artificial intelligence
- Social network analysis
- Information visualization

In the context of inquiry- and project-based learning interventions, an LA approach might be utilized to investigate ways in which students are using an e-learning management system in conjunction with their inquiry and project creation. A teacher may decide to design and deploy such an environment to support the inquiry and collaborative endeavors of students. Wikis have also been discussed as coordinating representations for student inquiry engagement. Such a system creates trace log data and site metrics that in some cases can be accessed and juxtaposed at the student and team levels of analysis for assessment purposes (Chu et al. 2011b).

Such data are made available via the wiki-based learning management system in the Globaloria project, which is a focus in Chap. 6 of this book. In Globaloria, a blended e-learning program involving project-based game design, students in the 2012/2013 school year used a Learning Management System (LMS) developed by an organization in NYC to develop individual online identities, engage in teamwork and collaboration, and for project management of the game development process. The LMS supported tasks and activities including:

- Game project file sharing (which in 2012/2013 included Flash and other software files, programming code, image files such as JPGs, and design documents).
- Ongoing documentation and archiving of the product management process.
- Updating of a schedule logging students' daily tasks completed.
- Communication and feedback among team and class members.
- Information-seeking for tutorial resources on programming help.
- Assignment completion (Reynolds 2016).

The system generates trace logs of wiki page edits and file uploads to the LMS. These data can be used to measure frequency of student engagement in a variety of page types.

To investigate whether student processes such as uses of the wiki contribute their learning outcomes, Reynolds and Chiu (2012) used this page edit and file upload log file data to aggregate frequencies and statistically measure their relationships to the scored game evaluations. To measure game outcomes, the authors used a rubric coding scheme that had achieved inter-coder reliability (2012). Findings indicated that the larger the number of constructive page edits and uploads to the wiki made by students, the more advanced were their game design learning outcomes. This result suggested that page editing (for instance, adding code to the site to share with peers) and uploading (for instance, archiving a Flash project .FLA file on the site so others could access it later) served to support, coordinate, and organize their game design efforts. This result adds validity to the claim that learning analytics process data such as log file frequencies for student uses of particular learning management system pages and resource types can be indicative of their success in achieving

learning objectives. Such a result needs to be tested further, though, considering variety in instructional context factors.

Another LA data source that LMS environments may generate includes page read and site visitation data (also called "click stream data"). In the case of Globaloria, page reads and site visitation were logged by Google Analytics, and these data were also accessible to the researchers. Google Analytics recorded page reads for non-editable information resource pages such as tutorials, that students were expected to access to help them problem solve programming challenges. Similar to page edits and uploads, findings for page *reads* also supported ways in which student information resource uses of the LMS contribute to learning outcomes (e.g., Reynolds 2016).

Overall, these data can be used by teachers and researchers as well as an organization such as Globaloria which develops a curriculum and/or web-based learning platform, to monitor and evaluate how students are using varied resources, and how such uses contribute to their learning (Reynolds 2014, 2016). Such a use of LA data can help teachers in assessment of individuals (e.g., some students are not using the resources enough or effectively, thus they may need greater information literacy support). LA data can also help teachers evaluate quality of a given curriculum (e.g., if they are piloting 2 solutions, and observe that student uses of one platform yields higher outcomes than uses of another platform, they may opt to use the higher yielding solution instead). LA data can also help organizations involved in curriculum and learning platform design to optimize particular features (e.g., if students are not using a particular resource in a suite of affordances, or if a particular resource is not linked to outcomes, then that resource's design might need to be improved). Educators are encouraged to empower themselves for data-driven decision-making, drawing on LA data when available. This is an up-and-coming domain of innovation within education, to watch.

8.2.5 *Assessing Media Awareness of Primary Four Students*

Media education in Hong Kong has been gaining importance since the turn of the century. Dissatisfaction with media performance and the undergoing education reforms are the major forces propelling the change. Media education was officially mentioned in the agenda of the Curriculum Development Council in 2000 (CDC 2000), hoping to equip students with sufficient media literacy to judge the credibility of news from the media (Lee and Mok 2007), meeting the goals of the education reforms to enhance students' critical and independent thinking skills (Education Commission 2000). However, it was unclear then how media education was to be incorporated into the curriculum framework. Research studies in media education were limited too.

This section discusses a project investigating media use and media awareness of primary four students (aged 9–10) from four schools in Hong Kong (Chu et al. 2010, 2014). In the era of information explosion, the media has established its

central status in knowledge and information circulation, and newer media is casting increasing influence alongside traditional media such as newspapers, television, and the radio. Little research has nonetheless been done on media education of young children, and stakeholders have shown themselves to be anxious about the impact of the media on children. The project thus attempted to fill the gap by exploring children's access to media, their media awareness and use patterns, and how well teachers know about children's media consumption.

In the project, teachers and students were given identical questionnaires on media awareness and media use patterns to be completed. A total of 332 questionnaires were collected, including 248 questionnaires from students and 84 from their teachers. Teachers from the four participating schools received the questionnaire before their students did to ensure that they could facilitate the students' understanding of the questions there. Teachers were invited to imagine how their primary four students would answer the questions, and to fill out the questionnaire from the perspectives of the students. During class time, the same questionnaire was administered on the students.

The questionnaire (see Fig. 8.2) was drafted in Chinese, the students' first language, for their ease of understanding. Organized in two sections, the first part contained open-ended questions concerning media use and awareness, in which students had to freely recall the names of different media while the second part required them to evaluate statements regarding media credibility on a Likert scale of 1–5.

The research questions focused on the following two aspects: (1) the media awareness and media use patterns of primary four students, and (2) the extent to which their teachers understand their media use and awareness patterns. The former was studied by identifying possible trends within students' answers, and the latter by comparing students' and teachers' answers.

Students were told to list their most frequently read newspaper. The top three listed ones were *Apple Daily*, *Sing Tao Daily,* and *Oriental Daily*, with the first two papers concurring with their teachers' choices. Despite this, teachers were unable to spot the popularity of other newspapers like *The Sun* and *Mingpao*. Students' awareness of free television channels was also assessed. Most were able to name two channels: *TVB* (which offers several free channels such as *TVB J2* and *TVB-interactive news channel* and other paid channels) and *ATV*.[1] Teachers were capable of pointing out the popularity of TVB over ATV, but were less successful in naming the TVB channel with the greatest popularity among students. There were also noticeable discrepancies between teachers' and students' answers about paid TV and radio services. The wide range of media forms mentioned further indicated that primary students in Hong Kong demonstrated a considerable level of media literacy, especially in their awareness of what there was on television.

Students were prompted to give reasons for choosing a particular newspaper, TV channel, and radio channel. For newspapers, rich content was the leading factor,

[1]ATV is no longer in operation from April 2016.

Questionnaire on media awareness and media use patterns

1. Please list three Chinese newspapers from Hong Kong:
   i. _____
   ii. _____
   iii. _____

2. Which of the above newspapers do you read most often? _____
   Why? _____

3. Please list two free TV stations in Hong Kong:
   i. _____
   ii. _____

4. Which of the above TV stations do you watch more often? _____
   Why? _____

5. Please list one paid TV service: _____

6. Does your family have a subscription to paid TV service at home? Yes/No
   If yes, which one?

7. Please list two radio stations:
   _____
   _____

8. Which radio channel from the above radio stations do you listen to more often?
   _____
   Why? _____

9. Do you surf the Internet? Yes/No
   If yes, how many hours do you spend online every day? _____

10. When you get connected to the Internet, which website will you first visit?
    _____

11. Do you agree with the following statements? (1 for strongly disagree, 5 for strongly agree)
    i. Generally speaking, news in the newspapers is reliable.
    ii. Generally speaking, news on TV is reliable.
    iii. Generally speaking, news from the radio is reliable.
    iv. Generally speaking, information on the Internet is reliable.
    v. I think it is important to read about the news every day.
    vi. I like knowing about the latest news.
    vii. I know how to distinguish true from unreliable news.

Fig. 8.2 Questionnaire on media awareness and media use patterns (Chu et al. 2010)

followed by interesting information. The influence of parents and teachers on their choice was not as huge as what the teachers expected. Similar results for TV channels were obtained. The results revealed that students were more content-oriented than what their teachers thought. They were able to make independent judgements on media consumption. Nevertheless, tabloids were more popular among students' choices of newspapers, including *Apple Daily* and *Oriental Daily*, which both featured on the top three. This is worth noting as the results showed that students selected which newspaper to read based on its content. But a large proportion of the respondents provided no answer to the question asking for their choice of radio channel.

Results denoted that around 85 % of the students had Internet surfing habits, with an average of 1.87 h spent on the Internet per day. Teachers were able to predict the first website that students visited (Yahoo!) but overestimated the frequency of their visits to online game-related websites. The popularity of the Internet may account for students' lack of familiarity with radio channels, since the Internet offers an alternative to radio programs (e.g., podcasts), and also substitutes radio channels to a certain extent.

Students were asked to comment on the reliability of the media. They considered the television to be the most reliable form of media, followed by the radio, newspapers, and the Internet, as expected by their teachers. They were also more cautious about the content of the media, especially the newer media, than their teachers thought. This suggested that traditional media is still regarded by them as important sources of information.

The study concluded that the students were autonomous in deciding on their choice of media, and did not rely merely on the new media, thereby demonstrating a considerable level of media literacy. Results of the study also indicated that teachers did not seem to fully understand their students' perspectives toward media use. Assessing students' media use patterns had implications for how media education models should be developed to maximize the benefits of media education on them. Findings pointed to the need for teachers to deepen their own understanding of students' media consumption habits in order to devise an effective, tailor-made media education curriculum for their students. Both under- and over-estimating students' access to, knowledge of and consumption of the media may lead to ineffective use of classroom time and implementation of teaching strategies.

8.2.6 *Measuring Knowledge Outcomes by Evaluating Product Artifacts*

The products of student inquiry-based learning projects often comprise not only research papers but also digitally produced texts such as audio- and video-files,

games, presentations, and various multimedia artifacts. Such artifacts represent the culmination of student knowledge-building during inquiry project-based learning. While their measurement and assessment does not span the entire breadth of the learning that occurs, the products of knowledge-building offer another useful object for observation and evaluation.

Teachers are generally accustomed to grading student papers, where a standard research outcome is a text-based report. It now becomes imperative to also prepare them for the evaluation of digital projects in inquiry-based contexts. In one study, Reynolds (2010) and Reynolds and Chiu (2012) adopted a content analysis approach in evaluating student game design artifacts in the Globaloria project discussed in Chap. 6. The approach is described as follows.

Game quality. To develop a variable of game quality for use in research, the authors conducted content analysis of all teams' final games. Neuendorf (2002) defines content analysis "as the systematic, objective, quantitative analysis of message characteristics" (p. 1). The purpose for evaluating games is to better understand the range of game mechanics (programming expertise), design attributes (esthetics) and messages students achieved (the results of their inquiry on a topic of interest, e.g., climate change, or social/cultural themes resident to their local environments).

Coding Scheme Development. The authors matched the definition of a "game" to a file that goes beyond a mere image to include some level of interactivity in which, at minimum, the file provides a response to the player, based on a player action. Defining a "game" at this minimal level of interactivity allowed the authors to code the full range of game files created by students from basic to advanced. The format of the game files students posted online included both .SWF (Small Web Format/Shockwave Flash) and .FLA project file formats.

The final coding scheme, presented in Appendix 8.3, included dichotomous variables for Actionscript programming codes that could reasonably be expected from introductory game design students which are measured for their presence or absence by a simple review of the .FLA and .SWF files (1 = present; 0 = absent). Furthermore, games were more subjectively evaluated for their design attributes built into the game, involving the following categories: visual and sound design elements, gameplay experience, concept development, and genre. Games were judged on a 3-point scale: 1 = Not present/insufficient representation; 2 = basic/introductory representation; 3 = well-developed representation.

To test inter-rater reliability, Reynolds and Chiu (2012) computed the kappas for each section of the coding scheme among a set of 3 coders who coded 10 % of the dataset with the following results: Actionscript programming evaluation, 0.85; visual and sound design evaluation, 0.81; gameplay experience evaluation, 0.87; concept development evaluation, 0.75. Appendix 8.3 presents this content analysis approach, which was used for research purposes but can be adapted as a rubric for practitioner use.

The resulting score for each game measures the quality of the game at the team level of analysis, and the team scores ranged from 16 to 61. The team score is interpreted to be the maximum extent of student expertise any one individual on that particular team may have reached. Note that this team approach to evaluation of a team-based artifact is quite different from the traditional school practice of individualized assessment as team-oriented evaluation is found to be able to incentivize more effective team collaboration and cooperation. Overall, such an outcome measure, if created and tested for reliability, can be used in educational evaluation and social science research.

Although inter-coder reliability assessment may not be feasible for the practitioner and rubrics are commonly utilized in education, such schemes for digital products are expected to become more widely available. The scheme approach shown in Appendix 8.2 can be adapted for educators who need to develop their own assessment of their students' inquiry project-based learning artifacts, considering the learning goals and objectives in one's own given context.

8.3 Conclusion

Various instruments for assessing twenty-first century skills and a sketch on what has been done worldwide to assess different skill components in the P21 framework have been introduced in the first part of this chapter. While an assessment tool may be well suited for the evaluation of more than one component of twenty-first century skills, multiple tools are often applied in assessing one particular component. Appropriate assessment methods need to be carefully chosen and adapted for both teachers' and students' benefits and needs.

It is the authors' goal to suggest an assessment approach based on empirical evidence drawn from different ways of monitoring students' work. Therefore, in the second part of the chapter, research projects conducted by them are presented. In all the case studies included, the researchers assess the respective skill components using evidence-based methods, including extracting data from records of student performance and collaboration during the intervention, self-assessments, custom-made assessment tools, application of learning analytics, questionnaires, and content analysis of artifacts produced by students. These assessment tools enable students to demonstrate their proficiency in various skills in a low-risk environment in comparison to standardized tests; they are also tailored to best reflect students' competency in the area under investigation, as one specific skill may need to be assessed in a different way than the next (Redecker and Johannessen 2013). With a suitable assessment method, students' competency can be effectively activated, and with quality assessment, teaching and learning is promoted to the students' advantage.

Appendix 8.1 Back-Translated Version of the IL Assessment Tool (Adopted from Chu 2012)

IL assessment tool
Question 1 (TRAILS, Sixth Grade General Assessment 1, Q1) Your teacher wants you to choose one religion and create a handout on that religion to introduce it. Which of the following subtopics below would you not include in the handout? A. World population B. Countries where the religion is found C. Customs and holidays D. Religious symbols
Question 2 (TRAILS, Sixth Grade General Assessment 1, Q2) When you are assigned a research project, the topic of the project is often too broad. You will have to narrow it down. In each pair of the topics below, select the topic that is narrower. A. Outer space B. Planets
Question 3 (TRAILS, Sixth Grade General Assessment 1, Q22) Which of the following is not a reason why you should cite your sources? A. Citing gives credit to the author or the first person of the idea. B. Citing shows that you have researched the idea. C. Citing allows another person to identify the complete work that you used. D. Citing tells readers where to purchase the complete work that you used.
Question 4 (TRAILS, Sixth Grade General Assessment 1, Q6) The assignment for a health class is to find facts about childhood obesity. You want to save time. Before typing "childhood obesity" into the Google search engine, which website should you check first? A. "Healthy Adults"—www.healthyliving.org—health information for adults B. "Lose Weight Now"—www.dietnow.com—several diet plans are explained C. "Kid's Health"—www.kidshealth.org—children's health topics are discussed D. "Food For Life"—www.foodgoodforyou.com—healthy food choices
Question 5 (TRAILS, Sixth Grade General Assessment 1, Q9) If you wish to find books by Cha Leung Yung, what kind of catalog search should you try? A. Title search B. Author search C. Subject search
Question 6 (TRAILS, Sixth Grade General Assessment 1, Q12) Your friend tells you about a website where you can download the latest songs that you hear on the radio for free. If you use this website for this purpose, which of the following will you violate? A. Right of privacy B. Copyright C. Freedom of information
Question 7 (TRAILS, Sixth General Assessment 1, Q10) You are told to create an informational pamphlet on animals. Your topic is giraffes. Select from the following websites one with the most credible information about giraffes. A. www.ourgiraffes.org—A site created by scientists studying mammals

(continued)

(continued)

B. www.sunnyschool.p6.hk/chan—A site about zoo animals created by Mr. Chan's sixth grade students
C. www.visitanddiegozoo.org—A site created by supporters of the San Diego Zoo
D. www.safaripictures.com—A site created by a tourist who visited Africa

Question 8 (TRAILS, Sixth General Assessment 1, Q14)
If you wish to find Joanne Kathleen Rowling's "Harry Potter," which library resource would you use?
A. Library catalog or online catalog
B. Video collection
C. Reference tool
D. Periodical database

Question 9 (TRAILS, Sixth General Assessment 1, Q16)
Read the following sentence and decide whether the sentence is a Fact or an Opinion.
"Smoking is bad for health."
A. Fact
B. Opinion

Question 10 (TRAILS, Sixth General Assessment 1 Q16)
Read the sentence and decide whether the sentence is a Fact or an Opinion.
"Smoking should be banned."
A. Fact
B. Opinion

Question 11 (TRAILS, Sixth General Assessment 1, Q18)
On a recent hike you saw an unfamiliar bird. You want to hear what sound this bird produces. Which library source would allow you to identify the bird and also hear the bird's sound?
A. A bird identification DVD
B. A printed field guide on birds
C. A general encyclopedia

Question 12 (TRAILS, Sixth General Assessment 1, Q15)
You have used a search engine to locate websites on the negative effects of drugs on teenagers. Below are some websites that your search retrieved. Read the site description and choose the one that would best meet your information needs.
A. www.addictionscare.com—a 24-h hotline regarding drug addiction in your community
B. www.teendrugabuse.org—describes how illegal drugs affect teenagers' brains
C. www.teenscenezeen.org—explains how to say "no" to drugs at a party
D. www.teendrugabusers.us—provides assistance to parents with troubled teens

Question 13 (TRAILS, Sixth General Assessment 1, Q23)
You are unsure about how to check out materials from the school library. Which source would not provide information on the library's checkout procedures?
A. The school newspaper
B. A pamphlet describing the library's rules and procedures
C. The librarian
D. Information signs at the checkout desk

Question 14 (TRAILS, Sixth General Assessment 1, Q24)
Your teacher wants you to write a report about Dr. Sun Yat Sen. Read the paragraph below and find the information that would help you answer this question: What did Dr. Sun Yat Sen accomplish during his presidency?

(continued)

(continued)

Dr. Sun Yat Sen was an important figure in modern Chinese history. He was the first provisional president of the People's Republic of China. He played an instrumental role in inspiring the overthrow of the Qing Dynasty and established the People's Republic of China, which makes him a world-renowned revolutionist. In 1925, Sun passed away because of liver cancer. A. Sun passed away because of liver cancer. B. Sun was the first provisional president of the People's Republic of China. C. Sun played an instrumental role in inspiring the overthrow of the Qing Dynasty and established the People's Republic of China. D. Sun is a world-renowned revolutionist.

Appendix 8.2 Questionnaire on Students' Familiarity with IL and IT Skills (Taken from Chu et al. 2011)

	Before the inquiry-based learning projects	After the inquiry-based learning projects	Perceived level of importance
	Level of familiarity 1 = Not familiar 5 = Very familiar	***Level of familiarity*** 1 = Not familiar 5 = Very familiar	1 = Not important 5 = Very important
A. Sources/databases:			
The use of the school library	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
School library's online catalog	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
The use of public libraries	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Public libraries'online catalog	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
WiseNews	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Google	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Yahoo	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
School/Library suggested websites	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Others, please specify			
B. Search skills & knowledge:			
Dewey classifications	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Reference books	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Newspapers	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Keyword search	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

(continued)

(continued)

	Before the inquiry-based learning projects	After the inquiry-based learning projects	Perceived level of importance
Boolean operator —And‖	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Boolean operator —Or‖	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Boolean operator —Not‖	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Others, please specify:			
C. IT skills and knowledge:	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Jiufang input method	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Canjie input method	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Writing pad	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
PowerPoint	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Excel	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Others, please specify:			

Appendix 8.3 Coding Protocol for a Digital Literacy Intervention Involving Student Inquiry-Based Learning and Construction of Digital Artifacts

1	**Game Design Programming Features, Basic (0 = not present; 1 = present)**	**How it looks in the Flash .SWF game file**	**.FLA Actionscript Code to search in Flash project file**	**SCORE**
1.1	roll over/roll out	When you place the mouse over or move the mouse off an object without pressing it, does something happen?	Symbol**.onRollOver** **or** Symbol**.onRollOut**	
1.2	Button presses	When you click a button on the screen, does something happen?	**onRelease**	

(continued)

(continued)

1.3	hit test/collision detection	When two objects on the screen overlap or collide, does something happen (such as points gained/lost, color change)?	Symbol**.hitTest** (otherSymbol)	
1.4	key press	Does something happen when you press the keys on the keyboard (like the arrow keys)?	if **Key.isDown**(Key. NAMEOFKEY) {effect of key press}	
1.5	on enter frame *	(You will have to check the FLA and code.)	**onEnterFrame** = function () {continuous looping code }	
1.6	timer *	Does this game have a time limit or do certain things happen at timed intervals? (You will have to check in FLA for the latter.)	**setInterval**	
2	**Game Design Programming Features, Advanced (0 = not present; 1 = present)**	**How it looks in the game design .SWF game file**	**.FLA Actionscript Code to search in Flash project file**	**SCORE**
2.1	drag and drop	Can you click and drag a symbol to move it and release the mouse button to drop it?	Symbol**.startDrag**(this); ***or*** Symbol**. stopDrag**();	
2.2	dynamic text or input text	Dynamic Text (e.g., score counter): the text changes depending on your actions—might have to find in Actionscript to ensure its dynamic text. Input Text: you can type text into a text field	Dynamic Text: **textBox.text** = "Your Text Here"; ‖ Input Text: output = input; or **. htmlText**	

(continued)

(continued)

2.3	preloader	Is there a preloader before the game appears?	var total = this.
			getBytesTotal();
			this.onEnterFrame =
			function(){
			loaded = **this.**
			getBytesLoaded();	

2.4	load sound	Does the game have sound?	my_sound**.attachSound** ("soundIdentifier")	
2.5	Physics engine	Do characters accelerate (as opposed to moving at a fixed rate)? Can they jump?	anything mentioning "**isJumping,**" "**velocity,**" "**landspeed,**" or "**gravity**" will denote presence of a physics engine, generally	
2.6	variables*	You will have to look in the code	**var** name = value;	
3	**Design, Content Evaluation:** Evaluate on a scale of 1 to 3	1 = Not present/insufficient representation; 2 = basic/introductory representation; 3 = well-developed representation		
3	**Visual and sound design elements**			
3.1	The visual design of the game creatively reflects the concept of the game (e.g., the designer uses color, shapes, and patterns so that the visuals and design reinforce the ideas in the game design plan)			
3.2	The visual/graphic style is consistent throughout the game (e.g., elements of color-scheme, character design, and gameplay objects are held consistent throughout the game)			
3.3	Sound is used to enhance gameplay (e.g., no sound = 1; if certain objects have sound embedded = 2; if sound is used to enhance experience overall = 3)			
3.4	Non-player moving characters and animated objects make the game dynamic (e.g., graphic animation elements are created and included as files)			
3.5	The game feels immersive, e.g., includes perspective-taking features in the artwork and player characters such as a first-person viewpoint for the avatar			
4	**Gameplay experience**			
4.1	The game instructions are clear and helpful to the viewer			
4.2	The game provides helpful feedback when the player advances or fails to advance through the game (e.g., quiz game provides feedback on a response; when a character dies, a life is lost or a message appears)			
4.3	The game is navigable and intuitive to use			
4.4	Game mechanics are simple to understand and learn, but offer increasing levels of challenge			
4.5	Based on their game design plan on the wiki, students have a clear idea of their "audience," and their game design as executed is appropriate for this audience			

(continued)

(continued)

5	**Concept development**	
5.1	The object/purpose of the game is clear from the beginning (the game provides context for the gameplay up front)	
5.2	The subject of the game is integrated throughout, not fragmented. See whether there is a message storyline or content present in the game. Is the topic/material complex and presented through the game?	
5.3	Any facts included are presented accurately and reflect research	
5.4	The educational material/game concept is not just presented as a quiz but is represented in a creative way in the gameplay. See whether game concept/storyline is coherently integrated with the mechanics and gameplay (e.g., challenge questions offered in an educational game are related to the action and gameplay)	
5.5	The game has an ending/conclusion that provides closure to the player	
5.6	The game design document on the wiki is thorough, clear, and understandable	
5.7	The paper prototype video is present and thorough in its initial outline and scope	

Note Life and career skills are not included in the table as they are relatively difficult to be measured quantitatively

References

Afflerbach, P. (2011). *Understanding and using reading assessment, K–12* (2nd ed.). Newark, DE: International Reading Association.

Arnone, M., Reynolds, R., & Marshall, T. (2009). The effect of early adolescents' psychological needs satisfaction upon their perceived competence in information skills and intrinsic motivation for research. *School Libraries Worldwide, 15*(2), 115–134.

Arnone, M., Small, R., & Reynolds, R. (2010). Supporting inquiry by identifying gaps in student confidence: Development of a measure of perceived competence. *School Libraries Worldwide, 16*(1), 47–60.

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals*. Handbook I: Cognitive domain. New York: David McKay Company.

Cachia, R., Ferrari, A., Ala-Mutka, K., & Punie, Y. (2010). *Creative learning and innovative teaching: Final report on the study on creativity and innovation in education in EU Member States* (No. JRC62370). Institute for Prospective and Technological Studies, Joint Research Centre.

Cha, S. E., Jun, S. J., Kwon, D. Y., Kim, H. S., Kim, S. B., Kim, J. M., et al. (2011). Measuring achievement of ICT competency for students in Korea. *Computers & Education, 56*(4), 990–1002.

Chan, M. Y. H., Chu, S. K. W., Mok, S. W. S., & Tam, F. (2015). *Fostering interest in reading and strengthening reading comprehension ability of primary school students using a children's literature e-quiz bank on the cloud*. Paper presented at the Quality Education Fund Project Seminar: Learning through Gamification: Cultivating a Love of Reading in Primary Students, The University of Hong Kong, Hong Kong, June 30, 2015.

Chu, K. W. S. (2009). Inquiry project-based learning with a partnership of three types of teachers and the school librarian. *Journal of the American Society for Information Science and Technology, 60*(8), 1671–1686.

Chu, S. K. W. (2012). Assessing Information Literacy: A Case Study of Primary 5 Students in Hong Kong. *School Library Research, 15*, 1–24.

Chu, K. W. S., Chow, K., Tse, S., & Kuhlthau, C. (2008). Grade 4 students' development of research skills through inquiry-based learning projects. *School Libraries Worldwide, 14*(1), 10–37.

Chu, D., Chu, S. K. W., Tavares, N., Siu, F., Chow, K., & Ho, S. Y. (2010). *Media awareness in the age of new media: A case study of Primary 4 students in Hong Kong*. Paper presented at ASIS&T 2010 Annual Meeting. Pittsburgh, PA.

Chu, S. K. W., Chin, Y. M., Wong, C. Y., Chan, I. H. Y., Lee, C. W. Y., Wu, W. W. Y., & Pun, B. L. F. (2011a). Using Google Sites in collaborative inquiry project-based learning at secondary school level. Paper presented at *9th International Conference on Computer Supported Collaborative Learning, The University of Hong Kong, Hong Kong.*

Chu, S. K. W., Tse, S. K., & Chow, K. (2011b). Using collaborative teaching and inquiry project-based learning to help primary school students develop information literacy and information skills. *Library & Information Science Research, 33*(2), 132–143.

Chu, C. B. L., Yeung, A. H. W., & Chu, S. K. W. (2012a). *Assessment of students' information literacy: A case study of a secondary school in Hong Kong*. Paper presented at CITE Research Symposium 2012, The University of Hong Kong, Hong Kong.

Chu, S. K. W., Lee, T. L., & King, R. B. (2012b). *Writing with others in wiki: An investigation of student collaborative writing in English among Chinese secondary students*. Paper presented at DGI-Conference 2012, Germany.

Chu, S. K. W., Tavares, N. J., Chu, D., Ho, S. Y., Chow, K., Siu, F. L. C., & Wong, M. (2012c). *Developing upper primary students' 21st century skills: inquiry learning through collaborative teaching and Web 2.0 technology*. Hong Kong: Centre for Information Technology in Education, Faculty of Education, The University of Hong Kong.

Chu, S. K. W., Lau, W. W. F., Chu, D. S. C., Lee, C. W. Y., & Chan, L. L. H. (2014). Media awareness among Hong Kong primary students. *Journal of Librarianship and Information Science,*. doi:10.1177/0961000614551448.

Chu, S. K. W., Kwan, A., Reynolds, R., Mellecker, R. R., Tam, F., Lee, G., et al. (2015). Promoting Sex Education among Teenagers through an Interactive Game: Reasons for Success and Implications. *Games for Health Journal, 4*(3), 168–174.

Claro, M., Preiss, D. D., San Martín, E., Jara, I., Hinostroza, J. E., Valenzuela, S., et al. (2012). Assessment of 21st century ICT skills in Chile: Test design and results from high school level students. *Computers & Education, 59*(3), 1042–1053.

Cooper, A. (2012). *A Brief History of Analytics*. CETIS Analytics Series, Vol 1, No. 9. Centre for Educational Technology & Interoperability Standards, The University of Bolton. Retrieved April 26, 2015 from http://publications.cetis.ac.uk/wp-content/uploads/2012/12/Analytics-Brief-History-Vol-1-No9.pdf

Crawford, J., & Irving, C. (2013). *Information literacy and lifelong learning: policy issues, the workplace, health and public libraries*. United Kingdom: Elsevier.

Curriculum Development Council. (2000). *Learning to learn: Key learning area, personal, social and humanities education*. Hong Kong: Hong Kong SAR Government.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011, September). From game design elements to gamefulness: defining gamification. In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments* (pp. 9–15). ACM.

Domínguez, A., Saenz-de-Navarrete, J., De-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J. J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers & Education, 63*, 380–392.

Education and Manpower Bureau. (2005). *Information literacy framework for Hong Kong students: Building the capacity of learning to learn in the information age*. Retrieved May 6,

2015 from http://www.edb.gov.hk/attachment/en/edu-system/primary-secondary/applicable-to-primary-secondary/it-in-edu/il_eng_7323.pdf

Commission, Education. (2000). *Education blueprint for the 21st century: Review of education system: Reform proposals consultation document*. Hong Kong: Hong Kong SAR Government.

Hatfield, E., Walster, G. W., & Berscheid, E. (1978). *Equity: Theory and research*. Boston: Allyn and Bacon.

Hawkins, K. T. (2012). *Thinking and reading among college undergraduates: An examination of the relationship between critical thinking skills and voluntary reading*. Ph.D. dissertation, University of Tennessee.

Hew, K. F., Huang, B. Y., Chu, S. K. W., & Chiu, D. K. W. (in press). Engaging students through game mechanics: Findings from two experiment studies. *Computers & Education*.

Hilton, M. (2010). *Exploring the intersection of science education and 21st century skills: A workshop summary*. Washington, D.C: National Academies Press.

Hobbs, R., & Frost, R. (2003). Measuring the acquisition of media-literacy skills. *Reading Research Quarterly, 38*(3), 330–355.

Honey, M., Fasca, C., Gersick, A., Mandinach, E., & Sinha, S. (2005). *Assessment of 21st century skills: The current landscape*. New York City, NY: Partnership for 21st century skills.

Judd, T., Kennedy, G., & Cropper, S. (2010). Using wikis for collaborative learning: Assessing collaboration through contribution. *Australasian Journal of Educational Technology, 26*(3), 341–354.

Koenig, J. A. (2011). *Assessing 21st century skills: Summary of a workshop*. USA: National Academies Press.

Kwan, A. C. M., Chu, S. K. W., Hong, A. W. L., Tam, F., Lee, G. M. Y., & Mellecker, R. (2015). Making smart choices: A serious game for sex education for young adolescents. *International Journal of Game Based Learning, 1*(5), 18–30.

Lee, A., & Mok, E. (2007). Media education in post-colonial Hong Kong: Cultivating critical young minds. In A. T. Nowak, S. Abel, K. Ross, Cresskill (Eds.), *Media education as pedagogy: Essays on identity and critical thinking* (pp. 177–199). Cresskill, NJ: Hampton Press.

Leuf, B., & Cunningham, W. (2001). *The Wiki way: Quick collaboration on the Web*. Boston, MA: Addison-Wesley.

López, O. S. (2010). The Digital Learning Classroom: Improving English Language Learners' academic success in mathematics and reading using interactive whiteboard technology. *Computers & Education, 54*(4), 901–915.

Lu, Y. Y., Chu, S. K. W., & Wei, V. (2016). *Examination of top performing primary students in an e-quiz bank "Reading Battle"*. Paper presented at the CITE Research Symposium 2016, The University of Hong Kong, Hong Kong.

Luzzo, D. A., Hasper, P., Albert, K. A., Bibby, M. A., & Martinelli, E. A., Jr. (1999). Effects of self-efficacy-enhancing interventions on the math/science self-efficacy and career interests, goals, and actions of career undecided college students. *Journal of Counseling Psychology, 46*(2), 233.

Meishar-Tal, H., & Gorsky, P. (2010). Wikis: What students do and do not do when writing collaboratively. *Open Learning, 25*(1), 25–35. doi:10.1080/02680510903482074.

Mullis, I. V. S., Martin, M. O., Kennedy, A. M., Trong, K. L., & Sainsbury, M. (2009). *PIRLS 2011 assessment framework*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

Notari, M., & Baumgartner, A. (2010). Do social skills play a role in collaborative project-based learning? Impact of the distribution of perceived social skills within learning groups in a Computer Supported Collaborative Learning-setting: an empirical pilot study. In *Proceedings of the 9th International Conference of the Learning Sciences-Vol 2* (pp. 288–289). International Society of the Learning Sciences.

Notari, M., Baumgartner, A., & Herzog, W. (2014). Social skills as predictors of communication, performance and quality of collaboration in project-based learning. *Journal of Computer Assisted learning, 30*(2), 132–147.

OECD. (2012). *PISA 2012 assessment and analytical framework. Mathematics, reading, science, problem solving and financial literacy*. Paris: OECD Publishing.

Redecker, C., & Johannessen, O. (2013). Changing assessment—Towards a new assessment paradigm Using ICT. *European Journal of Education, 48*(1), 79–96.

Reynolds, R. (2010). *Developing a content analysis approach to measuring student engagement in Constructionist game making learning environments*. Paper presented at the Annual Conference of the Association for Education in Journalism and Mass Communication (AEJMC) 2010, Denver, CO.

Reynolds, R. (2014). *Understanding and measuring student Inquiry and Resource Use Processes, and their Contribution to Outcomes, in "Guided Discovery-Based" Learning*. Paper presented at the Information Interaction in Context Conference (IIiX) 2014: Workshop on Searching as Learning, Regensburg, Germany.

Reynolds, R. (2016). Connecting student information resource uses to learning outcomes in a guided discovery-based game design program. *iConference*. Philadelphia, PA, March 2016.

Reynolds, R., & Chiu, M. (2012). Contribution of motivational orientations to student outcomes in a discovery-based program of game design learning. In *Proceedings of the International Conference of the Learning Sciences (ICLS), July 2012, Sydney, Australia*.

Reynolds, R., & Harel Caperton, I. (2009). *The emergence of 6 contemporary learning abilities in high school students as they develop and design interactive games and project based social media in Globaloria-West Virginia*. Paper presented at the Annual Convention of the American Education Research Association (AERA) April 2009, San Diego, CA.

Sandars, J. (2012). Technology and the delivery of the curriculum of the future: Opportunities and challenges. *Medical Teacher, 34*(7), 534–538.

Sayed, Y. (1998). *The segregated information highway: information literacy in higher education*. South Africa: Juta Academic.

Scharf, D., Elliot, N., Huey, H. A., Briller, V., & Joshi, K. (2007). Direct assessment of information literacy using writing portfolios. *The Journal of Academic Librarianship, 33*(4), 462–477.

Siemens, G., & Baker, R. S. (2012). Learning analytics and educational data mining: towards communication and collaboration. *Proceedings of the 2nd international conference on learning analytics and knowledge* (pp. 252–254). Canada: ACM.

Sternberg, R. J. (2006). The Rainbow Project: Enhancing the SAT through assessments of analytical, practical, and creative skills. *Intelligence, 34*(4), 321–350.

Torrance, E. P. (2000). *Research review for the Torrance Tests of Creative Thinking: Figural and verbal form A and B*. Bensenville: Scholastic Testing Service.

Walsh, A. (2009). Information literacy assessment Where do we start? *Journal of Librarianship and Information Science, 41*(1), 19–28.

Woo, M. M., Chu, S. K. W., & Li, X. (2013). Peer-feedback and revision process in a wiki mediated collaborative writing. *Educational Technology Research and Development, 61*(2), 279–309.

Wu, W. W. Y., Chu, S. K. W., Chan, H., Wong, J., Tse, S. K., Tavares, N. J., & Mok, S. W. S. (2014). *Strengthening students' reading comprehension ability (both Chinese and English) through developing children's literature e-quiz bank on the cloud*. Paper presented at 19th International Education and Technology Conference, Hong Kong.

Zurita, G., Nussbaum, M., & Salinas, R. (2005). Dynamic grouping in collaborative learning supported by wireless handhelds. *Educational Technology and Society, 8*(39), 149–161.

Part IV
Summary and Conclusions

Chapter 9
Summary and Conclusions

This book has taken the reader through a journey of being introduced to inquiry project-based learning approaches derived from the theories of social constructivism, and understanding the link between such approaches and the emerging new national and association standards frameworks for twenty-first century learning and teaching. It has considered collaborative teaching and learning as well as knowledge sharing through the employment of social media (such as wikis) and learning management system platforms, and has explored avenues through which gamification and game design can offer motivational support and opportunities for quality learning in inquiry-based contexts. We have also discussed ways in which teaching practices may vary in different educational settings, given cultural, socio-political and infrastructural diversities, as seen from the variations that exist across the projects in schools in Hong Kong, China, Switzerland, and the U.S. The book has put forward a range of strategies that facilitate twenty-first century skills education from the perspective of pedagogical design, teacher education and assessment methods.

Just before the publication of this book, the National Education Technology Plan of 2016 was released in the U.S., updating the guidelines mapped out in the original Plan of 2010. The latest plan recommends that a number of bold actions be devised to affirm the role of technology in helping close the achievement gaps seen in U.S. schools of today. Central to the imperatives of the new plan are the following augmentations (Smith 2015):

- **Redesigning teacher preparation programs**, shifting from a single technology course to deliberate and integrated use of technology throughout a teacher's preparation, and developing minimum standards for higher education instructors' technology proficiency
- **Universally offering equitable access to technology and connectivity** inside and outside of school, regardless of students' backgrounds
- **Supporting the shift to high-quality openly licensed educational materials, in electronic form**, in place of traditional textbooks

S.K.W. Chu et al., *21st Century Skills Development Through Inquiry-Based Learning*, DOI 10.1007/978-981-10-2481-8_9

- **Implementing universal design principles for accessibility** across all educational institutions and including these principles in teacher preparation programs
- **Improving technology-based assessments**, covering embedded assessment during online instruction, offering real-time feedback for students and diagnostics for educators
- **Establishing a robust technology infrastructure for today's schools**, meeting current connectivity goals, with ongoing ease of augmentation toward future demands.

Teacher professional development figures especially large in the new updated plan, which calls for educators to be trained to teach in both blended and online learning formats, and technology competencies for teachers and professors to be developed. It is our sincere wish that this book may be useful for these purposes, by providing educators around the world with practices, activities, tools, and assessment strategies backed up by rigorous educational research. We believe that this will aid educators to more effectively implement technology-supported inquiry project-based learning interventions that lead to strong benefits in their students' dispositions, practices, expertise, and knowledge in core curriculum domains as well as in twenty-first century skills.

Here, we summarize and make some further recommendations for the stakeholders who bear important responsibilities in bettering education in the changing technology-driven landscape of the modern day. These groups of people include teachers, teacher educators, school librarians, policymakers, and education researchers.

9.1 For Teachers

Educators' roles are evolving worldwide, as shared recognition grows for the need to include students' twenty-first century skills as learning objectives. To enable this shift to actualize more fully, a new vision toward education and a mind open to adaptation and change are key assets for educators in this era. Inquiry-based learning methods require teachers in some ways to "let go" of their role as the absolute authoritative knowledge source of the classroom, and more readily adopt student-centered approaches that meet learners' needs at the individual level. For the development of twenty-first century skills, supporting students will also require teachers to become more technologically advanced themselves in order to serve more aptly in their capacity as expert guides.

While social constructivist and inquiry-based approaches encourage a facilitative role, this does NOT mean that educators expect students to teach themselves. Students need guidance and support via what Kuhlthau et al. (2007) call a Zone of Intervention. Research suggests that interventions involving student inquiry and

information-seeking on project topics in a core content knowledge domain and/or help-seeking for technical problem-solving (e.g., graphic design or coding and programming) require thoughtful scaffolding on inquiry processes (Reynolds 2016a). It may not suffice to define a task for students such as creating a digital story-telling project or digital game/simulation, and then immediately send them straight down a self-driven path of inquiry. Students need concrete and structured guidance and instruction on information literacy in order to learn how to successfully locate, evaluate, interpret and utilize information resources to meet their task-driven inquiry goals and to produce an outcome-based artifact (2016a). The best teachers have a special capacity—critical discernment—to know when to impart information skills and knowledge at strategic, optimal moments in the instructional sequence for successful inquiry PjBL implementation.

At times, teachers are advised to hold back their instincts to solely instruct and lecture, and to create room for students to contemplate, inquire, and formulate ideas for themselves. At other times but not always, teachers may need to closely and tightly intervene. Striking this balance is the artful work of educators. Experimentation with inquiry-based learning models calls upon one to embrace the messiness and uncertainties that may arise in the process. Educators must learn to welcome the challenge of diving in at the right moment, without possessing all the knowledge and skills they might need upfront. Rather, a disposition for co-learning alongside students will be key. Educators must have the courage to start from where they are, and build the pedagogical and technical domain skills as the evolution continues. Without such a drive and faith in our own adaptation, students will not have a solid example to follow and will remain stuck in a classroom culture of top-down instruction and rote learning.

Below are some broad principles to encourage pioneering teachers to launch into implementing inquiry-based learning pedagogy:

- Understand the twenty-first century world and its expectations on its citizens
- Reflect on the role of education specific to the needs of the learner
- Choose engaging inquiry PjBL projects, inquiry processes, and innovative digital artifacts reflecting student knowledge construction
  - For instance, stay current on new trends in robotics, geo-tracking mobile app development and other new artifact forms for digital construction toward which your students may apply their inquiry processes
- Practice student-centered pedagogies
- Minimize the insistence on lectures
- Adopt the role of facilitators
- Scaffold and structure student learning as needed, given observations in situ on skills gaps

- Interweave information literacy instruction that supports students' creative work, in consultation with the school librarian
- Accept learning as a messy and nonlinear process
- Welcome collaboration and sharing among colleagues
- Commit themselves to lifelong learning.

9.2 For Professors and Teacher Educators

The higher education curriculum can be designed or modified in a way that fosters the acquisition and development of twenty-first century skills among learners; for example, by making use of interactive information technology in teaching and/or offering more project opportunities for learners to collaborate with one another and take an active role in co-constructing knowledge. However, none of these can be done effectively unless reinforced by appropriate pedagogies and skills. Therefore, professors in schools of education, teacher educators, have a vital role to play in facilitating teachers' adaptation to the drastic changes of the education landscape. Teacher training institutions should help prospective and in-service teachers realize the demands and challenges that the education sector faces in the twenty-first century. Being able to situate education in the time of the students, instead of perceiving education input as being something static over time, is essential for teachers to reflect on their teaching philosophy and goals to better cater for learner needs. In addition to grooming teachers' ability to critically reflect on and rethink education, it is crucial that teacher educators provide adequate support to teachers in order to help them cultivate, develop, and strengthen the knowledge and skills needed for twenty-first century education. To be specific, twenty-first century skills such as information literacy, media literacy, and information and communication technology (ICT) literacy are relatively new to many teachers who used to be receiving a more traditional type of education which focused more on reading literacy. Deliberate attention and support should be provided in helping these teachers, especially senior teachers, who may tend to struggle in the acquisition of IT skills, which are deemed necessary assets in inquiry learning pedagogies. In brief, teacher educators are encouraged to

- Understand the twenty-first century world and its expectations on its citizens
- Reflect on the role of education specific to the needs of the learner
- Stay updated on trends in the learning sciences and information sciences around inquiry-based and social constructivist pedagogical techniques

- Adapt program curricula annually to reflect the constantly evolving knowledge base of best practices
- Provide adequate support to teachers to acquire new knowledge and skills, including hands-on internship and practical experiences
- Offer courses that promote student-centered pedagogies
- Model student-centered pedagogies in their own teaching
- Take up and model the role of facilitators, who also stay closely in tune with students' individualized learning needs
- Support teacher trainees in their own pathways of discovery and feelings of agency and creative license to innovate.

9.3 For School Librarians

On top of preparing teachers' mindset to try out a new approach to teaching and learning, it is of paramount importance to foster tighter collaboration among teaching staff, school librarians, and administrative staff within schools in order to cultivate an environment more conducive to multi-disciplinary learning among students. Particularly, the authors see great potential in teacher librarians taking up further responsibilities in the teaching and learning process (Chu 2009). There has been a growing wealth of literature on school librarianship which advocates librarians' leadership as well as decision-making and practice based on best available evidence with a focus on demonstrating positive outcomes and contributions to schools' learning goals (DiScala and Subramaniam 2011; Todd 2009). Evidence-based practice nurtures librarians to be reflective practitioners, actively seeking ways to help students meet their learning goals (Todd 2002). With their expertise in information literacy, they are of enormous value to the school in supporting teachers in guiding students toward completing plagiarism-free inquiry learning projects (Lee et al. 2016). School librarians are also urged to adopt a more proactive role to promote a habit of reading among students through, for instance, organizing library reading sessions and making use of technologies (e.g., e-books and e-quiz platforms, see Wu et al. 2014) so as to scaffold students' development of reading skills. All in all, they are advised to grasp opportunities to

- Take up a more active role in teaching information literacy
- Seek and welcome collaboration with the teaching staff
- Offer advice and recommendations to teachers on the development of information literacy among students

- Utilize research evidence to inform practice
- Consider specific needs of students with diverse capabilities
- Organize activities to promote students' reading habits and foster their reading skills, in addition to inquiry process skills.

9.4 For Policymakers

A study by Reynolds and Chiu (2015) has found that inquiry project-based learning interventions such as those advocated in the Globaloria game design project discussed in Chap. 5 can attenuate digital divide effects. In particular, results of this study have indicated that substantive digital literacy interventions like these erase the effects of gender on digital skills, reduce the effects of socioeconomic status as measured by parent education, lessen the effects of prior school achievement and show preliminary evidence that the project removes the effects of race. Notable shifts in digital skills have also occurred that ameliorate digital divide gaps usually seen in the general population, which, if implemented at a larger scale, is believed to present sizable changes in greater populations. This result signals to policymakers that school-based programs aiming to nurture learners' twenty-first century skills may be helpful to close the digital divide gaps.

From the literature and our own understanding of the world's education system, we note that examinations in the form of standardized assessment have become, to a considerable extent, a central part of national education systems worldwide. As much as it is the most direct tool to evaluate students' knowledge, it is also a severe hindrance to inquiry-based twenty-first century skills education. Most standardized tests exert extensive pressure on teachers to give direct input to students and generate an examination-oriented learning atmosphere, rather than facilitating student learning by means of inquiry (Ming Pao 2015; Nadworny and Kamenetz 2016). Teachers are not the only ones who are affected by this pressure; students become less motivated to engage in self-initiated learning too because of the heavy weighting of tests and examinations on their report cards. Educators and policymakers involved in formulating education policies should be mindful that apart from subject knowledge, they also have to adequately assess how students make use of other twenty-first century skills such as critical thinking, reading skills, and digital literacy. Standardized assessments can hardly be a comprehensive tool to help students consolidate and help teachers evaluate how well students have mastered the skills.

Teachers will be driven to establish a more inquiry-based and student-centered learning ethos when the education system is designed to help students become adaptive to the ever-evolving society. Existing rigid frameworks neglect students' genuine needs. We propose that space in the block schedule be created for

alternative methods such as those espoused herein to be tried out. Assessments should not be seen to be an obstacle to the acquisition of twenty-first century skills. This challenge is obviously substantial, but the stakeholder audience of this book can make a difference by sponsoring and implementing programs such as those advocated in the various chapters, and by highlighting as well as advocating successful implications and cases if and when positive results are yielded. This work is happening in some schools that we have reported on in our research studies discussed in the book. A "make-it-happen" attitude is essential to success.

Furthermore, developing digital literacy among teachers and students requires more than just making use of IT in teaching; the authority needs to understand that without sufficient government support, technology will never reach the desired level to facilitate the inclusion of twenty-first century skills into the syllabus. Not only should government policies align with the commitment to provide training opportunities to teachers, policymakers should also reconsider the government's budgets so that adequate financial support is provided to schools to enhance the infrastructure for twenty-first century classrooms. To encapsulate what has been stressed, policymakers need to

- Adjust curriculum and assessment methods in accordance to twenty-first century skills
- Provide sufficient opportunities and time for teachers to undergo additional training specific to the needs of a twenty-first century classroom
- Ensure financial support is provided to schools to furnish and maintain IT-equipped classrooms.

9.5 For Researchers

Collaborative and coordinated efforts of education researchers alongside technology developers, education policymakers and educators will help ensure that student learning experiences are of a high quality. One of our aims is therefore to make this book a launching point for more research in the field of twenty-first skills education. In the disciplines of the learning sciences and computer-supported collaborative learning, researchers target at generating new learning and instructional design theories and principles that address effective design of learning technologies. Many studies in these disciplines draw upon design-based research as a methodological paradigm (see Barab and Squire 2004; Cobb et al. 2003; Wang and Hannafin 2005; Williamson and McGregor 2011). Studies involving educational technology research and development in these areas are quite rigorous and advanced, and associated with the aims of twenty-first century skills education.

The studies cited here in the entire book employ a variety of research methods and pedagogies. There are a number of outcomes that might be measured, linked to the objectives of any given intervention. Reynolds (2016b) notes the extent to which definitions of "digital literacy" vary, and our book has synthesized many of the policy frameworks for digital and information skills. Consequently Reynolds (2016b) offers a newly proposed modular framework for the conceptualization of "digital literacy" that invites anyone using it in research to (a) explicate the theoretical, conceptual, and pragmatic terrain underscoring their definition of digital literacy, (b) establish operational linkages for the instruction and student practices being implemented to meet the objectives stated in the given definition, and (c) re-evaluate the researcher's measurement operationalizations for digital literacy (e.g., knowledge tests, surveys, interviews, content analyses). Educators may further want to define rubrics and assessments to be utilized in the classroom, as we have discussed in Chap. 8 of the book. This framework aims to invite greater coordination of studies for comparison; if researchers choose to adopt it, then those meta-analyzing studies will be able to discern commonalities and differences among definitions, instructional practices, and operationalizations, strengthening the clarity of the evidence base documented in Reynolds (2016b).

In this vein, the authors of this book invite more research from other learning and instructional design researchers to enable us all to gain more insights into what are the necessary and sufficient conditions in intervention design (e.g., program duration and frequency, activity structure, and sequencing, resources needed, teacher involvement) for achieving learner success for any intended outcome (e.g., digital literacy, subject area knowledge gains). Researchers are encouraged to consider both short- and long-term effects as well as the varying life and career effects that have been included in several of the twenty-first skills frameworks. Ultimately, instructional design research serves to bring about good practices. The book is a step in this direction as it pertains to inquiry project-based learning. We are keen on advancing our understanding of what we might expect for the lower and upper limits of the effects that may be realized, and what kinds of sustainability requirements are essentially needed for achieving such effects and for influencing real social mobility potential—an integral educational objective and a broadly shared goal for the authors with the hope that students will benefit.

Education researchers have to work actively and collaboratively to identify open questions—theory- and evidence-based—for future research. We have to establish and maintain a community of scholars for disseminating findings and best practices that emerge from research so that the chances of reinventing the wheel are minimized and effort in bettering education can be redoubled. Through collaboration, we strive to locate comparable contextual factors that are shared and that vary in different implementation models so as to help frontline teachers and policymakers adopt pedagogical approaches that maximize teaching and learning specific to their contexts. Researchers are also prompted to propose comparative studies and analyses across different education settings to deepen our understanding of the role played by cultures in pedagogies that harness twenty-first skills development. To move forward, our recommendations are to

- Formulate open questions for future research
- Identify comparable contextual factors for implementation considerations
- Propose comparative studies across different contexts
- Develop a community of scholars for sharing findings and best practices.

9.6 What is Next?

While suggestions have been made for individual stakeholders to reflect on, educational professionals have to bear in mind that there is no perfect formula that will work in all education systems; different countries must adopt varying policies in light of their historical and cultural diversities. It is also not possible to improve an education system in one night, have all students equipped with twenty-first skills in one go and have all classes conducted in an inquiry-based setting without any challenge. It takes continuous, concerted, and tremendous efforts for education practitioners and researchers to work out and enforce education policies that are most suitable for one place. The most significant thing is to be able to discover and face the prevailing problems in the system and to courageously seek ways to overcome them with appropriate policies and interventions. Provided with the affordances and constraints of the existing education contexts around the world, this book puts forward various forms of interventions that have been proven to be effective in promoting and sustaining students' development of twenty-first skills.

As the authors of this book are finalizing on the manuscript of this chapter, we are approaching the year 2017. While we are dedicated to addressing the rapid changes in the twenty-first and preparing our younger generation for the future world, human beings are moving swiftly toward the twenty-second century in which more uncertainties are awaiting us. Good education should always think ahead of time and get people ready to cope with upcoming challenges. Rome is not built in one day. Efforts to transform education must be fueled by robust research and frontline observation. It is therefore imperative to embrace a new vision toward education for the future and a liberal mind open to adaptation and positive change to empower our learners with the knowledge and skills to thrive in the increasingly complex and fast-moving world of tomorrow. We offer encouragement for those who will apply the ideas presented, in the swiftly shifting education environments *of today*—across continents.

References

Barab, S. A., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *The Journal of the Learning Sciences, 13*(1), 1–14.

Chu, S. K. W. (2009). Inquiry project-based learning with a partnership of three types of teachers and the school librarian. *Journal of the American Society for Information Science and Technology, 60*(8), 1671–1686.

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher, 32*(1), 9–13.

Curriculum Development Council (CDC), HKSAR. (2014). *Basic education curriculum guide: To sustain, deepen and focus on learning to learn*. Hong Kong: Curriculum Development Council. Retrieved December 16, 2015 from http://www.edb.gov.hk/attachment/en/curriculum-development/doc-reports/guide-basic-edu-curriculum/BECG_2014_en.pdf

DiScala, J., & Subramaniam, M. (2011). Evidence-based practice: A practice towards leadership credibility among school librarians. *School Libraries Worldwide, 17*(2), 59–70.

Kuhlthau, C. C., Maniotes, L. K., & Caspari, A. K. (2007). *Guided inquiry: Learning in the 21st century*. Westport, CT: Libraries Unlimited.

Lee, C. W. Y., Chu, S. K. W., & Yue, J. O. (2016). *Plagiarism-free inquiry project-based learning with UPCC pedagogy*. Paper accepted to the ASIS&T 2016 annual meeting, Copenhagen, Denmark.

Ming Pao. (2015, November 29). 教局拒言撤TSA允或大調整 認運作有問題 待2月專家小組有結論再議. Retrieved January 12, 2016 from http://news.mingpao.com/pns/dailynews/web_tc/article/20151130/s00001/1448820456298

Nadworny, E., & Kamenetz, A. (2016, January 8). Why kindergarten is the new first grade. *NPR*. Retrieved January 12, 2016 from http://www.npr.org/sections/ed/2016/01/08/462279629/why-kindergarten-is-the-new-first-grade?ft=nprml&f=462279629

Reynolds, R., & Chiu, M. M. (2015). Reducing digital divide effects through student engagement in coordinated game design, online resource uses, and social computing activities in school. *Journal of the Association for Information Science and Technology (JASIST).*

Reynolds, R. (2016a, February). Relationships among tasks, collaborative inquiry processes, inquiry resolutions, and knowledge outcomes in adolescents during guided discovery-based game design in school. *Journal of Information Science: Special Issue on Searching as Learning*.

Reynolds, R. (2016b). Challenges in defining, designing for, and measuring "Digital Literacy" development in learners: A proposed framework. *Educational Technology Research & Development*.

Smith, D. F. (2015, December 10). 6 ways the new National Education Technology plan could help close achievement gap. *Ed Tech Magazine*. Retrieved online December 12, 2015 from http://www.edtechmagazine.com/k12/article/2015/12/6-ways-new-national-education-technology-plan-could-help-close-achievement-gap

Todd, R. J. (2002). Evidence based practice: The sustainable future for teacher-librarians. *Scan, 21*(1), 30–37.

Todd, R. J. (2009). School librarianship and evidence based practice: Progress, perspectives, and challenges. *Evidence Based Library and Information Practice, 4*(2), 78–96.

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development, 53*(4), 5–23.

Williamson, K., & McGregor, J. (2011). Generating knowledge and avoiding plagiarism: Smart information use by high school students. *School Library Media Research*, *14*.

Wu, W. W. Y., Chu, S. K. W., Chan, H., Wong, J., Tse, S. K., Tavares, N. J., Mok, S. W. S et al. (2014). *Strengthening students' reading comprehension ability (both Chinese and English) through developing children's literature E-quiz bank on the cloud.* In Paper presented at 19th International Education & Technology Conference, Hong Kong.