21ST CENTURY SKILLS DEVELOPMENT: LEARNING IN DIGITAL COMMUNITIES: TECHNOLOGY AND COLLABORATION

by

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DISSERTATION ABSTRACT

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Title: 21ST Century Skills Development: Learning in Digital Communities: Technology and Collaboration

This study examines some aspects of student performance in the 21st century skills of Information and Communication (ICT) Literacy and collaboration. In this project, extant data from the Assessment and Teaching for 21st Century Skills project (ATC21S) will be examined. ATC21S is a collaborative effort among educational agencies in six countries, universities, educational research groups, high tech innovators and the multinational corporations Cisco, Intel and Microsoft. ATC21S demonstration tasks explore the use of digital literacy and collaborative problem solving constructs in educational assessment. My research investigates evidence from cognitive laboratories and pilots administered in one of the ATC21S demonstration scenarios, a collaborative mathematics/science task called “Global Collaboration Contest: Arctic Trek.” Using both quantitative and qualitative methods, I analyze student work samples. Specifically, I (i) develop a rubric as a measurement tool to evaluate the student assessment artifact “Arctic Trek Notebook” for (a) generalized patterns and (b) trends that may indicate skill development in collaborative learning in a digital environment and (ii) conduct descriptive studies among the variables of student age and student notebook characteristics. Results are intended to inform instructional leaders on estimates of

student ability in virtual collaboration and to make suggestions for instructional design and professional development for online collaborative learning assessment tasks in K-12 education.

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CHAPTER I

INTRODUCTION

The late 20th and early 21st centuries have seen unprecedented global sociocultural change driven by advances in technology. Continuing expansion in the use of technology for all facets of society is changing the world economy and social structures. Economists cite the influences of globalization on the U.S. Labor Market, including an increased need for workers with expert thinking, metacognition, problem solving, and complex communication skills (Levy & Murnane, 2007).

Such workplace competencies are leading to the development of research sometimes described as 21st century skill development. The Partnership for 21st Century Skills (2003) defines this as "knowing how to use knowledge and skills in the context of modern life" (p. 6). More specific definitions of 21st century skills are emerging from a variety of sources in business, education and government. In order to address the myriad of definitions and provide some commonality, the project involved in this dissertation research, Assessment and Teaching for 21st Century Skills project (ATC21S), arrived at a model framework for such skills by assembling an international group of experts to examine and compare curriculum and assessment frameworks for 21st century skills that have been developed around the world in recent years (Griffin, McGaw, & Care, 2012).

Frameworks examined from more than a dozen different organizations included the U.S. National Academy of Sciences and the International Society for Technology in Education (ISTE), as well as the Organization for Economic Cooperation and Development (OECD) and United Nations. Ten over-arching skills that spanned across many frameworks were identified by ATC21S to typify the skills necessary for the 21st century. The ten skills were grouped into four areas: ways of thinking, ways of working, tools for working, and living in the world (Binkley et al., 2012). Demonstrations by the project are focusing on the assessment and development of skills in two areas, as examples of what can be done to assess 21st century skill building:

- Ways of working: communication and collaboration (or teamwork).
- Tools for working: information literacy and ICT literacy.

In ATC21S, researchers, cognitive scientists, measurement professionals, technology leaders and policy scholars have come together to facilitate the integration of 21st century skills in K-12 systems through the creation of evidence-centered design performance assessments for formative purposes; technology-based tools for scaffolding metacognition, social networking, collaborative participation, and semantic analysis; developmental frameworks and progressions; and models for enhancing domain knowledge through infusion of 21st century skills. The goal is to demonstrate assessment and learning models that define 21st Century Skills.

This dissertation project examines student performance from an ATC21S research project in one area of the new framework, Information and Communications Technology Literacy, or ICT Literacy. The purpose of the study and research questions will be introduced in an upcoming section. But first, in order to situate the purpose of the study, 21st century skills as educational goals and the relationship of such skills and abilities with the new U.S. Common Core standards will be briefly explored in the following two sections.

21^{st} Century Skills as Educational Goals

The recent infusion of Web 2.0 media that supports access to creation, production and interconnectivity has fundamentally changed the global cultural ecology further by enhancing global communication structures, reforming authoritative knowledge, restructuring the economy, and organizing political change through mass participation supported by social media (Dede, 2009; Ito et al., 2008). 21^{st} century skills such as ICT Literacy are identified as crucial to a knowledge-based economy and for the innovation necessary to meet increasing global challenges including climate change, sustainable food systems, medical advances and economic structures (Balistreri et al., 2011; Wagner, 2008). The benefits of having a society competent in 21^{st} century skills may include enhancing productivity and global competitiveness, minimizing unemployment, improving income distribution, supporting social cohesion, and facilitating individual participation in democratic processes (Organization for Economic Cooperation and Development, 2005; World Bank, 2003).

Today's youth, often described as digital natives, were born into a technology-infused culture, and have spent their formative years with access to social media (Prensky, 2001). In 2000, 17 million Americans aged 12-17 used the Internet (Lenhart, Purcell, Smith, & Zickuhr, 2010; Rideout, Foehr, & Roberts, 2010). In 2005 this number rose to 21 million or 87%; and by 2009, 93% of teens used the Internet (Lenhart et al., 2010). Table 1 describes current patterns of technology and social media use among teens.

In a 2008 survey of schools across all 50 states of the U.S., 100% of schools examined had one or more instructional computers with Internet access and an average student-computer ratio of 3:1. About 97% of the schools had one or more instructional

Table 1

Teen Internet Access and Social Media Use in the U.S.

Technology Behaviors	% of Teens in U.S.
Online daily	63%
Use social network sites	73%
Own a computer	68%
Own an mp3 player	79%
Own a portable gaming device	51%
Use handheld device for Internet access	25%
Access the Internet wirelessly	55%

Note. Adapted from "Social media and young adults," by A. Lenhart, K. Purcell, A. Smith, and K. Zickuhr, 2010, for the Pew Internet & the American Life Project.

computers with Internet access directly in the classroom, and 58% of the schools had laptops on mobile carts for shared use (Gray, Thomas, & Lewis, 2010).

While having access to computers in schools is rising, formally educating students within school settings and via standards-based approaches for the development of 21st century skills is dependent on many other factors as well. These include the ability to adequately define specific and generalized skills and constructs of interest, or areas of the curriculum where such skills could be integrated, then creating curricular pathways to teach these skills and approaches to accurately assess such skills. Involved in all of this are key components of both teacher knowledge and school leadership knowledge of how to support student learning and to appropriately advance educational goals in these areas. This will be discussed in more detail in subsequent sections.

Common Core State Standards and 21st Century Skills

The new Common Core State Standards (CCSS), now adopted by forty-five states and the District of Columbia, hope to provide shared clear and consistent expectations for learning, defining what students should understand and be able to do at each grade level, with an emphasis on college and career readiness. While all states had standards prior to the adoption of the Common Core, the standards were often vastly different from state to state, sometimes leading to differences in achievement levels across state lines; the CCSS are one step towards a national model of education. Common Core State Standards Initiative was led by the states, supported by the National Governors Association Center for Best Practices (NGA) and the Council of Chief State School Officers (CCSSO). The standards were developed in collaboration with teachers, school administrators, content experts and researchers in education, and the development process included feedback on draft standards from a variety of K-12 education stakeholders, including teachers, parents, the business community and civil rights advocates (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010).

21st century skills, as described in frameworks listed in Chapter I, are supported both implicitly and explicitly in the CCSS. The Common Core Standards are organized by English Language Arts (ELA) and Mathematics. ELA, for instance, includes literacy standards for history, social sciences, science and technical subjects, addressed through both reading and writing strands. The 21st century skills critical thinking, collaboration, communication and information literacy are supported, for example, in the following

ELA standards: under Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6–8, Standard 8 asks students to:

> Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010, p. 66)

In the Speaking and Listening Standards for K-5, Comprehension and Collaboration, Standard 1 asks first grade students to:

> Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups: a. Follow agreed-upon rules for discussions (e.g., listening to others with care, speaking one at a time about the topics and texts under discussion). b. Build on others' talk in conversations by responding to the comments of others through multiple exchanges, and c. Ask questions to clear up any confusion about the topics and texts under discussion. (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010, p. 23)

21st century skills are integrated throughout the CCSS for Math with overarching Mathematical Practices that cross grade levels. These overarching practices include asking students to (a) make sense of problems and persevere in solving them; (b) reason abstractly and quantitatively; and (c) construct viable arguments and critique the reasoning of others (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010). Outside of the CCSS framework, a number of states have adopted 21st century skills standards that include problem solving, communication, using technology, working in teams collaboratively, making multi-disciplinary connections, using media for learning purposes, engaging in lifelong learning, using complex thinking, ethical thinking, and responsible citizenship (Dede, 2009; P21, 2008).

The ATC21S Project

This dissertation project and its associated research questions are intended to contribute to the research base on student abilities in the 21st century skills of virtual collaboration through Information and Communication Technology (ICT) literacy, also sometimes described as digital literacy in the United States. Potential implications as such research begins to accumulate include informing instruction and helping to guide leadership in formulating teacher professional development and student support in collaborative learning and digital literacy in K-12 education.

Given the wide range of institutions calling for improving student skills described in 21st century frameworks, the need exists to develop new research-based pedagogical strategies that support 21st century skills. This includes creating and piloting assessments aligned with integrating 21st century skills into teaching and learning (Balistreri et al., 2011; P21, 2003), which is a focus of this project.

This study uses extant data from the Assessment and Teaching for 21st Century Skills project (ATC21S). ATC21S is a collaborative effort among international ministries of education in six countries, universities, educational research groups, high tech innovators and the multinational corporations Cisco, Intel and Microsoft. ATC21S demonstration tasks explore the use of digital literacy and collaborative problem-solving constructs in educational assessment. Using data from cognitive laboratories and pilot assessments administered in 2011, I analyze student work samples from a collaborative mathematics/science task called "Global Collaboration Contest: Arctic Trek" developed by ATC21S as a demonstration scenario to assess information and communication literacy.

Purpose of Study and Research Questions

Teachers in many settings are being encouraged to adopt tools of digital collaboration and use them in classroom instructional settings, but little research is available to help teachers understand how to evaluate and assess such work, and the instructional trends they should look for as they integrate participatory media tools into the classrooms. The purpose of this study is to examine student work samples from a collaborative task in a digital environment and describe patterns or trends of collaborative skill evident in the body of work to be reviewed. The intent of this study is to contribute to research that may inform practice for instructional and assessment strategies in this emerging area of collaboration in a digital environment. This study will further the understanding of the cognitive and social processes involved in collaborative digital literacy skills for students at ages 11, 13 and 15. The results of the study may also help inform instructional leaders on conceptions of student work in virtual collaboration and guide leadership in formulating instructional design to support collaborative learning in K-12 education.

In this project, I develop a rubric as a measurement tool to evaluate the student assessment artifact "Arctic Trek Notebook" for generalized patterns of skill development and to investigate trends in collaborative learning through a digital environment. I conduct descriptive studies among the variables of student age and student notebook characteristics.

My research questions are as follows:

RQ 1. Does the use of the artifact Arctic Trek collaborative Notebook fall into distinct patterns that reflect levels of skill development or show trends in collaborative learning through a digital environment?

1a. Can categorical patterns be identified?

1b. Can these patterns be seen as types of performances referenced by collaboration literature, based on this data set?

RQ 2. Will descriptive analysis show that levels of Notebook use have a relationship with student age, for this sample?

1a. Do data displays show patterns clustering by age?

1b. If patterns are evident in 1a, are there important trends to be seen in the age-related patterns, such as will more advanced digital collaboration patterns be seen for younger or older students, in this data set?

RQ 3. Given the results of analysis in RQ 1-2 above, do performance patterns identified in the digital collaborative work products suggest connections to student instructional support as examined through an instructional leadership focus?

Regarding RQs 1 and 2, my hypothesis is that I will find patterns associated as trends, and they will have a relationship with age. There is some speculation in the field that the youngest age groups may show the most advanced digital collaborations skills because of higher exposure over more years, due to the rapid pace of technology growth. However, the literature to date supports that students in the 11-year-old group would be expected to have more difficulty with collaboration, even technology-based collaboration, due to maturity-related issues such as goal orientation; lack of refined situational awareness; less mature patterns for social orientation; and broader group orientation. Therefore, I hypothesize that the trend will show more success with digital collaboration as age increases from the 11-year-old to the 13-year-old group and then subsequently for the 15-year-olds who overall as a group I expect to show the highest traits on the rubric, though considerable variability within group may be seen. Note that these hypotheses are based on cross-sectional data only. Comparisons of patterns are for select groups of the age-related cohorts. More about the sampling characteristics will be described in the Methods chapter.

Regarding RQ 3, my approach will be to consider what connections with trends from RQs 1-2 can be made to the research literature regarding student instructional support. RQ3 subsumes many large questions clearly worthy of entire research projects in their own right for 21st century skill dispositions. My intention here is to begin documenting RQ3 concerns associated with trends from RQs 1-2 based on this data set, to establish a landscape for future work. This will help to underscore instructional leadership concerns that need to be addressed for helping to support 21st century skill development. RQ3 also points out the alignment of assessment and instruction, particularly important in domains such as 21st century skills that are beginning to appear in educational standards frameworks in many countries but do not yet have an established formal instructional basis in many schools today.

Literature Review

Education is a comprehensive discipline, with a web of strands crossing many areas. 21st century skills, ICT literacy, and collaboration are three such interdisciplinary, multiple-skill encompassing topics. Each of these topics will be taken up in turn in this literature review and discussed contextually regarding history, policy, and practice related to these topics.

While 21st century skills and ICT are rather new to the field of education, collaboration has a long history of various iterations that are likely to inform such practice in a digital and 21st century context. Moreover, 21st century skills, collaboration and ICT have all been variously defined and described in the field of education. My intent in exploring the literature was to cast a wide net with regards to how these topics may be defined, named, and conceptualized, and follow strands that presented depth in development of the combination of collaboration and ICT, both encompassed by and outside of a stated 21st century skills context.

Search Terms and Systems

A review of the literature on 21st century skills was conducted June through December 2011, using the UO library collection and online databases of Academic Search Premier, Education Resources Information Center (ERIC), EBSCOHOST and Google Scholar. Keywords searched included broad topics such as 21st century skills, 21st century skills in K-12, 21st century skills in education, 21st century skills for students in K-12, collaboration skills for students in K-12, cooperative learning skills in K-12, and performance assessments. Topics with a narrowed focus such as computer-supported collaborative learning, computer-supported collaborative learning K-12, and ICT and collaborative learning K-12 were generated through the broader literature, and pursued further. A search of websites hosted by organizations that promote 21st Century Skills was also conducted, including research-based sites, university-based sites, school sites, and professional development sites.

The literature search included education policy and practices related to 21st century skills, collaboration, and technology. Background information on these topics were necessary to address current constructs regarding collaboration and technology use in instructional settings, and how these skills tie to 21st century frameworks for student learning. Information was also needed on current assessment practices in these areas. As these curricular areas are relatively new to K-12 education, searching the literature for mechanisms of instructional design and professional development to enhance teacher efficacy in instructing in these areas was also included in the literature search. The literature search was at least initially inclusive of educational research at any level before narrowing it to K-12, in part because the structure of most K-12 systems makes educational research difficult, and even findings at college level may be applicable to K-12 settings, depending on the content and format of the study.

Search Results

The literature search revealed a variety of topics and sub-topics to be reviewed in order to reflect material relevant to the various disciplines that intersect among the constructs of 21st century skills, collaboration, and technology in education. Table 2 displays the search terms and search systems used to access literature, prior to narrowing the searches with the criteria for inclusion described in the next section.

A large percentage of the articles retrieved described a set of ICT and 21st century standards and the rational for such standards. Many of the articles researched were related to curricular frameworks for technology and technology integration. Additional resources were gleaned from reference lists and citations of articles reviewed through the search process, as well as from websites promoting the inclusion of 21st century skills in education.

Table 2
Literature Search Terms and Systems

Search Term	Search Engine
21st century skills in education	Google Scholar
21st century skills in K-12	Google Scholar
21st century skills and education	EBSCOHOST
Collaboration skills for students in K-12	Google Scholar
Cooperative learning skills in K-12	Google Scholar
Computer-supported collaborative learning	Google Scholar
Computer-supported collaborative learning	Academic Search Premier
Computer-supported collaborative learning in K-12	Google Scholar
ICT skills in K-12 education	Google Scholar
ICT and collaboration	Google Scholar
Performance Assessments in K-12	Google Scholar
Performance Assessments for 21st century skills	Google Scholar
Technology and global economic change	Google Scholar
Technology use among youth in the United States	Google Scholar

Criteria for Inclusion

Criteria for inclusion following the search described above included retaining articles appearing in peer-reviewed journals specific to the description of 21st century skills and associated instructional models; technology integration for 21st century skills; collaboration and computer-supported collaborative learning; and assessment of 21st century skills. Policy papers and Reports authored by foundations and government agencies were reviewed. Another set of literature included was book chapters in theoretical, methodological, and professional development books and reference handbooks.

Articles specific to outcomes of 21st century skills were not reviewed, although sometimes outcomes were mentioned as a portion of the discussion in the citations retained. Literature published from 1980 to 2012 was included. Relevant citations prior to 1980 were sparse and less informative than the more current literature on 21st century skill development, so were not included. However it should be noted that some of the collaboration literature extends considerably earlier than this search period. Where appropriate, major collaboration research contributions are mentioned in various portions of this dissertation work regardless of this specific date framework.

An Environment of Global Social and Economic Change

The literature identified frequently addressed how both the economy and workplace have changed in recent years, and cited impacts on workforce training and education (Levy & Murnane, 2007; OECD, 2005). Global competition, the pace of change, new organizational structures and the nature of how work is accomplished have necessitated a workforce of flexible, collaborative, continuous learners with complex cognitive skills (American Management Association, 2010). These skills are described as necessary for workforce preparedness and business success in what is termed the knowledge age as producers attempt to hold a lead on innovation in world markets through knowledge as the center of economic production. The knowledge economy requires new skills, education and training, as the demand for highly skilled, digitally literate workers increases and the demand for less skilled workers is reduced (World Bank, 2003).

Globalization of the economy brings opportunities for expansion as well as pressures from global competition. Team-based workplaces with flatter or decentralized organization are increasingly dependent on personnel networks of cross-functional teams and technology-related or technology-inclusive job descriptions (Stuart & Dahm, 1999). Other trends impacting the workforce are smaller work units, knowledge networks, and shorter product cycles that increase the need for innovation, resulting in the need for workers to take more personal responsibility for their work (Huitt, 1999; World Bank, 2003).

New Workforce Requirements Beyond Basic Skills

Previous "industrial age" skills for success in the workplace were characterized by punctuality and routine: following instructions; recognizing the authority of the supervisor; using routine functions that remained constant over time; and working on monotonous tasks for extended periods (Huitt, 1999; Secretary's Commission on Achieving Necessary Skills, 1991; World Bank, 2003). Some scholars have noted that the public school system and other institutions in our society prepared students under those conditions (Huitt, 1999).

However, in the knowledge age, businesses need adaptable employees who are lifelong learners; able to update or learn new skills independently; communicate effectively; work independently; use critical thinking, problem solving and decision making skills; work in teams to manage information; and produce new knowledge (P21, 2008). Workers must show such flexibility in order to respond to the changing knowledge and skill requirements of the workplace. Many jobs require abilities in multi-tasking, project work, and self-management, with strong interpersonal skills and the ability to negotiate and influence (P21, 2008; Stuart & Dahm, 1999).

As early as 1991 the U.S. Dept of Labor report, *What Work Requires of Schools* (SCANS, 1991), outlined new thinking skills, personal qualities, and competencies for schools to address beyond the foundational basic skills in order to prepare students for new workplace skills in the 21^{st} century. The Secretary's Commission on Achieving Necessary Skills (SCANS) identified Thinking Skills, Personal Qualities and Competencies necessary for success in the future economy as follows: creativity, decision-making, problem- solving, and knowing how to learn; responsibility, sociability, self-management and integrity; and information skills, interpersonal communication and teamwork, systems thinking, and technology proficiency (SCANS, 1991).

From an organizational perspective, corporations and industry have also participated in conversations on the need for new skill development. The American Management Association (AMA) surveyed over 2,000 managers and executives in 2010 regarding workforce preparation and the nature of skills required for success in today's economy. Participants were represented most heavily by business, financial services and manufacturing, and one quarter of those surveyed represented companies with 10,000 or more employees. Eighty percent agreed or strongly agreed that students would be better prepared to enter the workforce with strong skills in critical thinking, communication, collaboration and creativity. Seventy-five percent of respondents expect these skills to become even more important in the future and stated that employees were both screened for and evaluated on their abilities in these skills (American Management Association, 2010).

The *AMA 2010 Critical Skills Survey* defined the skills as follows:

- **Critical thinking and problem solving**: including the ability to make decisions, solve problems, and take action as appropriate.
- **Effective communication**: the ability to synthesize and transmit your ideas both in written and oral formats.
- **Collaboration and team building**: the ability to work effectively with others, including those from diverse groups and with opposing points of view.
- **Creativity and innovation**: the ability to see what's not there and make something happen.

AMA 2010 Critical Skills Survey (AMA, 2010).

Figure 1. American Management Association 2010 Critical Skills Survey

Socio-Cultural Change and Educational Technology Policy

In 1983 the influential report *A Nation at Risk* identified computer science as a basic requirement for high school graduation and recommended that students understand and be able to use computers for information and communication purposes in work and personal capacities (National Commission on Excellence in Education, 1983). Rapid advances in technology over the past thirty years have led to transformation of socio-cultural ecology worldwide, and early primary students now master basic computer use.

U.S. Department of Education reports discuss the transformative potential of technology in re-configuring teaching and learning to support the development of skill sets emerging as important for participation in future economies. Other important priorities for technology use were described as supporting rich applications of teaching and learning as described by the emerging field of cognitive science, and enhancing learning accommodations (Web-based Education Commission, 2000; U.S. Department of Education, 1996; U.S. Department of Education, 1997).

However, this emerging transformation with technology also coincided in the U.S. with the movement for basic skills competency as exemplified by the federal No Child Left Behind (NCLB) Act of 2001. An emphasis under NCLB on high stakes testing of core content as measured by standardized, multiple-choice tests included little focus on such skills as described above (Klieman, 2004; Pecheone & Kahl, 2010). For instance, while NCLB recommended technological literacy as a benchmark for 8^{th} grade, assessments were not put in place to measure such literacy system-wide. Manifestations of the basic skills accountability system under NCLB were described by some scholars as narrowing the curriculum as teachers taught to the test in the few areas being assessed or used test-prep materials in order to increase test fluency and raise scores in basic skills (Baker, 2008; Darling-Hammond & Adamson, 2010; Herman, 2008).

This is changing as research has highlighted the need for the development of higher order thinking skills as necessary precursors to college and career readiness (Conley, 2010; Pecheone & Kahl, 2010). Internationally benchmarked assessments such as the Programme for International Student Assessment (PISA) illustrated the relative weaknesses of student in the United States in higher order thinking skills as compared to students in other countries (Baker, 2008; Balistreri et al., 2011). In the U.S., the new common core standards adopted across most states push the standards beyond basic skills to enhance college and career readiness and promote 21st century skills as integrated aspects of learning across numerous areas (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010).

Technological Enhancements and Digital Literacy

In an analysis of twenty years of educational technology policies, Culp, Honey and Mandinach (2003) outline policies planning the use of technology to extend teaching and learning processes through student use of data collection and analysis; increased use and critical review of diverse information resources; integration of higher order thinking and communication skills; and use of technology and multimedia to assess more "complex dimensions of learning" through performance and portfolio based assessment (p. 5, 2003). These policies are aligned with 21st century learning frameworks that suggest using educational technology and new media not as an end in itself, but as part of the learning culture and should be infused throughout disciplines.

Specifically in digital literacy, research and development teams note the tension evident throughout plans and policies between using educational technology as an addition to the conventional curriculum and pedagogy in place since the industrial age, or for reform appropriate to the knowledge age with transformative pedagogical change made possible by the new tools and changing patterns of access and response to information (Culp et al., 2003; Harris, Mishra, & Khoeler, 2009). For instance, according to the National Science Foundation sponsored Teaching, Learning and Computing Survey, 12% of high school social studies teachers, 17% of science teachers, and 24% of

English teachers reported using computers in the classroom on more than 20 occasions over a 30-week period. The most frequently reported uses were factual information gathering, typing, and drilled practice for skill mastery (Becker, 2001; Smeets, 2005).

With information gathering cited as a main use for technology, this helps to suggest one pathway for building toward more integrated 21st century skills in some classrooms where appropriate, through a research and evidence-gathering process. While there are many small-scale and innovative research-based applications of such activities for school use, inquiry-oriented instruction including collaboration and the infusion of educational technology remains used by relatively small numbers of teachers nationwide, and appears to be supported by teacher training in student-centered pedagogies (Inan, Lowther, Ross, & Stahl, 2010; Smeets, 2005).

More transformative pedagogical change through the use of technology is often aligned with constructivist methods such as problem-based, project-based or inquiry-based learning, exemplified by collaborative, student directed learning guided by a teacher-facilitator and the use of curriculum, which may be open source, supported by technology. This potential shift in pedagogy has implications for the reform of teaching and learning as well as the structure of K-12 systems. However, researchers have reported that in studies of wide-spread educational computer use, technology in U.S. schools is rarely used for such 21st century skills as problem solving, creating products, and communication to share perspectives with others (Inan et al., 2010).

Educational priorities as outlined by current Elementary and Secondary Education Act (ESEA) policy Blueprint for Reform include raising test scores in Math and English Language Arts both overall and for disaggregated subgroups of students, and increasing graduation rates from high school (U.S. Department of Education, 2010). Technology is used as an administrative tool in education for data collection and management to support student achievement through computer-based assessments and dissemination of the data, tracking of attendance, behavior, and RTI data as well as internet use for information access (Culp et al., 2003; Harris et al., 2009). Researchers describe how the political pressure to increase scores in narrowly defined domains has had a limiting effect on other content areas and types of skill development in K-12 systems, while in social and business realms *outside of schools* Web 2.0 media has led to an explosion in the use of technology by school-age populations in informal contexts and outside of formal education systems (Dede, 2010).

Technology Use Among Youth Aged 8-18

Growth in Internet use among youth rose steadily throughout the first decade of the 21st century, and youth ages 8-18 use the Internet in an increasing variety of ways, see Table 3 for changes in technology use among youth between 2004 and 2009. A study by Lenhart et al. (2010) reported that 76% of teens get news online, doubling between 2000 and 2009; 55% of teens in 2009 obtained health related information online, 71% used the internet to make purchases, and only 13% of teens state that they do not use the Internet, largely due to access related to low income.

Among U.S. teens, 11 to 14 year olds logged more media use than 8-11 or 15-18 year olds, and Black and Hispanic youth logged more media time per day on average than White youth in the Kaiser study, though the Pew study found that Black youth had less access to internet than other groups and that Black youth primarily accessed the Internet over mobile wireless devices (Lenhart et al., 2010; Rideout et al., 2010).

Table 3

Reported Technology Use Among Children 8 – 18

Media Use	2004	2009
Play Games Online	52%	81%
Read News Online	38%	76%
Own Laptop	12%	29%
Own iPod or mp3 Player	18%	76%
Own Cell Phones	39%	66%
Total Daily Media Exposure (time in hours: minutes)	8:33	10:45
Multi-tasking Proportion	26%	29%
Total Daily Media Use (time in hours: minutes)	6:21	7:38

Note. Adapted from "Generation M2: Media in the lives of 8 to 18 year olds" by V. J. Rideout, U.G. Foehr, and D.F. Roberts, 2010, Kaiser Family Foundation.

Youth and new social media. Researchers of social media and ICT among teens found that youth use social media to extend friendships, connect and network with interest-driven groups, and engage in self-directed, peer-based learning; they create, express, and distribute their work and achieve outcomes through exploration more than they pursue predefined goals (Agosto and Abbas, 2010; Ito, et al., 2008; Rideout et al., 2010). The influence of social media and the youth focus on peer-based, exploratory learning has implications for the traditional authoritative role of adults in education; out of school, teens have increasingly become self-directed learners. Teachers and parents are often less technologically literate than the youth, and youth are engaging in pedagogy not supported by traditional learning structures (Ito et al., 2008).

Ito et al. (2008) use the term “networked publics” to describe public culture supported by online networks that bridge mass media and online communication with active participation in distributed social networks to produce and circulate culture and knowledge. Networked publics are increasingly the access to participation in both local and distributed communities, among friendship and interest-driven groups as well as political entities. The ability to fully participate in our society today is somewhat dependent on the ability to navigate new media as both a savvy consumer and producer (Ito et al., 2008; OECD, 2005; World Bank, 2003).

The Education-Technology Gap

Student experiences of technology within and outside of the classroom are disparate; out of school technology use tends to be fluid, flexible, social and creative while in-school use tends to be structured; limited to drills and practice, information search in restricted modalities, and defined demonstration of knowledge such as typing a paper (Buckingham, 2006; Kleiman, 2004; Ito et al., 2008).

Digital literacy in schools, when defined operationally, is typically a functional definition such as how to operate hardware or use software with basic skills for certain operations, a focus on internet searches, and safety or security issues (Buckingham, 2006; Dede, 2005; Balistreri, et al., 2011; Harris et al., 2009). Information and Communication Technology (ICT) researchers suggest rethinking the definitions of ICT or digital literacy and education—that new media have become more than tools; they are infused with emerging cultural norms, and modes of expression for both private and public engagement (Buckingham, 2006; Dede, 2009; Jenkins, Clinton, Purushotma, Robinson, & Weigel, 2006; Smeets, 2005).

Newer frameworks call for increasing use of critical evaluation of online content, while researchers cite this critical evaluation as a skill lacking in many students. In addition, Web 2.0 social media supports diverse forms of ICT literacy, with different skill sets and manners of communication required depending on the content and connotation of the media use, such as friendship-driven or interest-driven participation, and students benefit from understanding differing social expectations in order to develop cultural and communicative competence in diverse media environments (Buckingham, 2006; Ito, et al., 2008).

Emergence, Definition and Development of 21^{st} Century Skills

21^{st} Century Skills were developed in tandem with changes in the workplace from the industrial age to the information age and what is now in post-millennium referred to as the knowledge age. Based on recommendations for 21^{st} Century workforce skills, stakeholders inclusive of businesses, higher education and government agencies simultaneously developed, defined and refined conceptual frameworks for 21^{st} century skills. Though initially more focused on technology integration and ICT literacy, frameworks have matured to include such topics as environmental and health literacy, descriptions of inquiry-based learning, promotion of second languages, and the use of performance assessments.

Integrating 21^{st} century skills into the K-12 education system is difficult due to a number of systemic issues, including that 21^{st} century skills are not necessarily content-driven and require an element of dynamic emergence that is not typically accommodated in current school curricular, assessment, or organizational structures. 21^{st} century skills are contextual and collaborative in juxtaposition to an education system often designed for linear individual work in more separated domains (Pecheone & Kahl, 2010). However, the inclusion of 21st century skills and pedagogy is gaining momentum and systemic support. The 21st Century Readiness Act has been introduced to allow the use of ESEA funds to develop, enhance and expand teaching of 21st century skills defined as (a) critical thinking and problem solving; (b) communication; (c) collaboration; and (d) creativity and innovation. The bill seeks to support 21st century readiness initiatives that combine 21st century skills with core academic subjects (Govtrack, 2011).

There are several independently developed conceptual frameworks outlining 21st century skills with general overlap in terminology, varying degrees of operationalization of skills and competency, and some specialization with regards to the infusion of skills with values and work habits. Some of the major frameworks are outlined in Table 4.

Table 4

21st Century Skills by Framework

Framework	Competencies	Relevance
EnGauge Framework from Metiri/NCREL (2003)	Digital-Age Literacy Inventive Thinking Interactive Communication High Productivity	Teaming, Collaboration, and Interpersonal Skills Interactive Communication Effective Use of Real-World Tools
Organization for Economic Cooperation and Development (2005)	Using Tools Interactively Interacting in Heterogeneous Groups Acting Autonomously	Use knowledge and information interactively Use technology interactively Cooperate, work in teams

Table 4 (continued)

Framework	Competencies	Relevance
International Society for Technology in Education ICT Skills (ISTE) (2008)	Creativity and Innovation Communication and Collaboration Research and Information Fluency Critical Thinking, Problem Solving, and Decision Making Digital Citizenship Technology Operations and Concepts	Use digital media and environments to communicate and work collaboratively Students apply digital tools to gather, evaluate, and use information Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity
Partnership for 21st Century Skills (P21) (2003 / 2009)	Core subjects and 21st century themes Learning and Innovation skills Information, Media and Technology Skills Life and Career skills	Communication and collaboration ICT literacy
Assessment and Teaching of 21^{st} Century Skills (ATC21S) Project (2010)	Ways of thinking Ways of working Tools for working Living in the world Digital Learning Communities	Communication and collaboration ICT and information literacy
College Board Global Education Framework (2011)	Empirically Based Knowledge and Skills; Higher-Order Cognitive, Metacognitive and Interpersonal Skills; Global dispositions, perspectives, and attitudes	Information literacy Communication and collaboration

New Media Strengths, Skills and Behaviors

New media skills, strategies and learning strengths such as in the use of audio, video and animation are embedded in some but not all frameworks. Learning strengths and styles are outlined by Dede (2005) as fluency in multiple media and valuation of each media type for the different communication options promoted; active learning based on collectively seeking, sieving and synthesizing media experiences rather than using a single information source; expression through both non-linear associational webs as well as linear media; and learning experiences co-designed by teachers and students for individualization (Dede, 2005).

Jenkins et al (2006) describe skills and behaviors related to rich use of new media including

- Play: experimentation as a form of problem solving
- Performance: the ability to adopt alterative identities for the purpose of improvisation and discovery
- Simulation: the ability to interpret and construct dynamic models of real-world processes
- Appropriation: the ability to meaningfully sample and remix media content
- Collective intelligence: the ability to pool knowledge and compare notes with others toward a common goal
- Transmedia navigation: the ability to follow the flow of stories and information across multiple modalities
- Negotiation: the ability to travel across diverse communities, discerning and respecting multiple perspectives, and grasping and following alternative norms

Dede (2009) created a Web 2.0 Use framework as follows:

- Sharing: communal bookmarking; photo/video sharing; social networking; and writer workshops
- Thinking: blogs; podcasts; and online discussion forums
- Co-creating: wikis/collaborative file creation: mash-ups/collective media creation
- Collaborative social change communities

21st Century Skills and Learning Theory

This wide range of elements can quickly become unworkable for instructional leadership, so an important consideration for this study is how views of digital literacy and the affordances of technology relate to learning theory. Cognitive scientists posit that learning occurs in context through accessing and constructing with prior knowledge; and is active, social and reflective, with learners utilizing metacognition to support self-direction, set learning goals and monitor progress (Barron & Darling-Hammond, 2008; Driscoll, 2002). To best support learning, some learning experts believe instruction should be learner centered, contextual, authentic, and supported by assessment (Donovan, Bransford & Pellegrino, 1999; Driscoll, 2002). Technology supports can be helpful in some of these areas, and the majority of 21st century skills frameworks include most of these components, with an emphasis on learner-centered, social, inquiry-based learning experiences in an authentic context (P21, 2003; Balistreri et al., 2011; Harris et al., 2009; Metiri, 2003). 21st century skills as typically defined support some of the best practices in cognitive research on learning: learning by doing, analyzing, communicating, processing and problem solving, and using transfer to different situations to support long-lasting and long-ranging educational efficacy.

Lifelong learning, called for in most 21st century frameworks, is described as a learner-centered, constructivist activity, with people learning in groups and from one another, with the teacher as a guide for resources and facilitator for individualized learning plans (World Bank, 2003). 21st century, lifelong learning, and global education share many traits describing a constructivist methodology, such as the call for creation and application of knowledge using diverse sources, and application of learner-centered and competency driven models in a flexible, decentralized manner with multiple learning options, modalities and settings.

Some researchers have described how traditional education models do not always well support research-based learning theory and the facilitation of 21st century competencies (Barron & Darling-Hammond, 2008; Dede, 2010). Students in these studies were found to primarily work alone and were often seen as passive recipients of knowledge from the teacher using a curriculum driven, acquisition and repetition model of learning. Some scholars have described how the emergence of new technologies combined with the new economic challenges of the knowledge age require transformation for future success in the new global society, but also while doing so help support educational best practices (Balistreri et al., 2011; Harris et al., 2009; P21, 2008; World Bank, 2003).

Collaborative Learning

Collaboration as an instructional strategy or process to support student centered learning is central to most 21st century frameworks and mimics the team-based structures common to the workplace in the 21st century model (AMA, 2010; Dede, 2010; SCANS, 1991). Literature on collaboration refers to cooperative learning, collaborative learning,

learning communities, distributed cognition, computer-supported collaborative learning, and joint or co-construction of knowledge, and these terms represent variations on the theme of students working together to maximize both their own and each other's learning in a small group situation. Table 5 presents a glossary of terms related to collaboration used throughout this study and referenced literature.

Table 5

Glossary of Terms for Types of Group Work Discussed

Term	Definition	Citation
Collaboration	Knowledge generation emphasized through shared meaning yet individual interpretation; meaning-making in the context of group interaction; interdependence highlighted; advances in collective knowledge prized	Scardamalia, Bransford, Kozma, & Quellmalz (2012) Stahl, Koschmann, & Suthers (2006)
Co-construction of knowledge	Knowledge is interactively achieved in discourse and may not be attributed as originating from any particular individual	Stahl, Koschmann, & Suthers (2006)
Computer-Supported Collaborative Learning (CSCL)	Group engagement in a group knowledge-building space, with channels of interaction between social and personal systems; may be asynchronous	Stahl, Koschmann, & Suthers (2006)
Cooperation	Both individual and group accountability are often present; may have distinct roles and division of labor;	Smith, Sheppard, Johnson, & Johnson (2005) Strijbos, Martens, & Joachems (2004a)
Cooperative Learning	Students work in teams to accomplish a shared goal with positive interdependence; both individual and group accountability are often present; may have distinct roles and division of labor; typically has structured interactions	Johnson & Johnson (2009) Smith, Sheppard, Johnson, & Johnson (2005) Strijbos, Martens, & Joachems (2004a)

Table 5 (continued)

Term	Definition	Citation
Group learning	Learning by groups—not in groups or individual learning by social processes	Scardamalia, Bransford, Kozma, & Quellmalz (2012)

Student collaboration on learning tasks is not an invention of the 21st century; cooperative learning strategies were documented in ancient Rome and China and have been practiced in European and American schools since the late 1700's. Francis Parker promoted cooperative learning in schools in the early 1800's, as did John Dewey in the 1920-30's in American schools. After a disappearance in favor of individualized, competitive instructional strategies, cooperative learning re-emerged in the 1960's and became widespread during the 1990's along with an emphasis on constructivist pedagogy (Smith, Sheppard, Johnson, & Johnson, 2005).

Johnson and Johnson (2009) initially described cooperative learning as students working together to accomplish shared learning goals. Smith et al. (2005) describe cooperative learning as students working in teams to accomplish a shared goal with positive interdependence, meaning that the performance of individual group members is dependent upon the performance of all other group members. The process often includes individual and group accountability; teamwork skills; and group processing. Stahl (2009) describes collaboration as incorporating the contributions of individuals into a group discourse and involving those individuals in maintaining and directing group processes; this is congruent with cooperative learning strategies. Stahl further illustrates collaboration as a spiraling cycle of individual to group enhancement where individuals contribute to the group and advance group cognition stimulating further individual thought processes, which are then contributed back to the group in the shared problem space, as the cycle continues.

In comparing cooperative and collaborative learning, Smith et al. (2005) suggests that while both modalities use peer group interaction to promote engagement and optimize learning, cooperative learning includes individual accountability while collaborative learning does not. This is not always the distinction that others use. Strijbos, Martens, and Joachems (2004a), for instance, synthesize distinctions such that cooperative learning is more structured with distinct roles and division of labor procedures, while collaborative learning is less structured though implying equality of contribution to the group effort. They note that cooperative learning and collaborative learning share more similarities than differences, and that the distinction may not be necessary in many contexts, where other terms could be used interchangeably.

In this paper I will use the terms cooperative learning and collaborative learning or collaboration interchangeably in the background and for discussion of instructional design and professional development, where cooperative learning is the more familiar and widely discussed concept in teaching practice; and use collaboration to describe my research, as the ATC21S Arctic Trek Notebook performance task is a group task that does not include individual accountability nor contains the structured interactions typical of cooperative learning strategies. I will use the terms digital collaboration and collaborative learning in a digital environment interchangeably to describe the act of collaborating through a technological medium.

Benefits of collaborative learning. Collaboration or cooperative learning aligns with cognitive science learning theory by providing opportunities for transfer of knowledge and skills through social interaction, problem solving and the metacognitive skills used to facilitate and reflect on group processes (Smeets, 2005). Collaboration among students promotes increased engagement by interactively working with materials and concepts, creating shared meaning, and using metacognitive skills to process learning and performance.

Research on cooperative learning dating as far back as 1924 documents that this modality can promotes higher individual achievement; retention and transfer of content and skills; creativity in problem solving; metacognition; persistence; increased social skills; higher self esteem; positive interpersonal relationships including trust and cohesion among students; and mutual positive regard across diverse groups of students (Smith et al., 2005).

However, there are difficulties related to the implementation of cooperative learning including developing norms and structures within groups that facilitate students working successfully together; choosing meaningful tasks that fit the cooperative work structure, such as open-ended, multi-faceted task requiring a variety of skills; and developing strategies for discussion and interaction with materials that support rich learning of discipline-specific content (Barron & Darling-Hammond, 2008). Cooperative learning has been found to be more effective when teachers made small groups of three to four students, structured individual accountability combined with positive interdependence, scaffolded group interaction, and adapted instructional materials and methods to small group instruction (Lou, Abrami, & d'Appolonia, 2001). These findings translate to increased teacher preparation and classroom management activity; not surprisingly, cooperative learning has been found most effective when teachers had extensive training and practice using this method (Barron & Darling-Hammond, 2008; Lou et al., 2001).

Researchers studying instructional practices for technology found that students working in small groups for technology instruction performed better than students working individually. Optimal performance of small groups was positively related to a social context including a difficult task, group size of 3-5 students, and little to no feedback or assistance available from the instructor (Lou et al., 2001). For example, students in pairs researching complex information by searching on the Internet to compose and support ideas had greater effectiveness than individuals, finding more information in less time with a greater range of search strategies, and showed greater proficiency in monitoring and evaluating their search behaviors (Lazonder, 2005).

Use of roles to facilitate group learning. Roles can promote group cohesion and responsibility through increasing group awareness, organizing group interaction, and directing individual efforts, leading to both positive interdependence and individual accountability (De Wever, Van Keer, Schellens, & Valcke, 2009). Roles can be assigned or self-selected, and are sometimes categorized as content roles, task roles, and maintenance roles. The use of roles is assumed to support functionality in collaborative learning, and was central to cooperative learning strategies as implemented in primary and secondary school settings.

In a study of roles in Computer Mediated Communication (CMC) among college students, Strijbos, Martens, Jochems, and Broers (2004b) found that the use of roles increased task-focused discourse and perceived group efficiency, but not overall performance as measured by grades. Other researchers found that scaffolded role assignment, where role structures were introduced early in the group process and then allowed to fade, had greater value for group performance (De Wever et al., 2009).

Group learning in face-to-face (FtF) modalities in primary and secondary settings typically involve the use of cooperative learning strategies for task distribution through role assignment. Theory holds that roles assigned to the group will facilitate interaction and full participation among group members by giving each an assigned role or purpose within the group and lead to better group efficiency, engagement and outcomes (Johnson, Johnson & Stanne, 1986). Role assignment has been posited to increase the positive interdependence and thus group cohesion (1986). Roles may be either content or process oriented. Many strategies for facilitation and implementation of roles were designed for FtF settings, such as numbered heads together, jigsaw, prompting or timekeeping. These roles were typically developed with purposive instruction and guided practice, and are a customary part of in-person classroom practice in U.S. schools.

Computer-Supported Collaborative Learning

Computer-supported collaborative learning (CSCL) is a relatively new research discipline that is also referred to as remote-located collaboration or computer supported group based learning. It is more widely researched internationally than in the United States, and often is associated more with post-secondary instruction than schooling for younger children. However it is a growing phenomenon as schools at all levels of instruction are adding more online or blended instructional venues each year.

Computer supported group based learning (CSGBL) mimics new 21st century workplace structures of remote-located teams collaborating on problem-solving and joint construction of knowledge in both synchronous and asynchronous modes. CSGBL is implemented much the same as FtF group work, and as the field is still emergent, there is a lack of continuity among institutions and instructors as to approaches for CSGBL programming and evaluation (Strijbos et al., 2004b).

Implications of virtual collaboration. Research studies have begun to investigate whether students working collaboratively in virtual environments may have their effectiveness perhaps hindered or enhanced from the reduction of in-person Face to Face (FtF) contact. Effects could result from reduction in the amount of social cuing that can occur in a non-visual interaction space, or alternatively from new interactions that may be possible with online tools, such as simultaneous text chat and audio signal available to all group members, supporting multiple channels of expression or reducing the anxiety of social regulation for teens by inserting the distancing abstraction of technology. In one study, students collaborating face-to-face showed more and higher levels of communication than the control group online, although a social presence could be created and maintained in the digital environment given social media tools (Lowry, Roberts, Romano, Cheney, & Hightower, 2006). Mutual construction of meaning may be hindered in virtual environments due to the lack of visual and physical cues, which can reduce social relatedness (Rienties, Tempelaar, Van den Bossche, Gijselaers, & Segers, 2008).

Large group size often is negatively correlated with quality two-way communication, due not simply to logistics but also to participant apprehension of evaluation, which tends to be higher in FtF and lower in virtual environments. The virtual environment appears to offset group size effects, such that a large group online will have greater participation and quality of communication than a large group in FtF environment (Lowry et al., 2006).

Temporal, relational and content dimensions are necessary to construct and support remote-located group interactions (Stahl, 2009). Social presence can be established without FtF interaction, or through virtual face-to-face with Web 2.0 social media tools. The additional features of a digital environment promoting social presence include parallelism, the ability for group members to contribute simultaneously; group memory; self-scribing; and group awareness. Also, the shared interface of a collaborative writing tool can offer a supported text environment that can lead to greater productivity, document quality, relationships and communication than static, non-interactive writing forums (Lowry & Nunamaker, 2003). The use of shared writing tools has allowed struggling learners to engage in collaborative note taking with more able peers or tutors, and has promoted increased participation among students collaborating in groups using collaborative writing tools for class discussion (Anderson-Inman, Knox-Quinn, & Tromba, 1996).

Evaluation of digital collaboration. Whether face to face or conducted virtually, communication is composed of several sub-constructs, including quality, appropriateness, richness, openness, and accuracy of receptive and expressive modalities. A major issue facing the research community for assessments in digital collaboration is the lack of continuity in evaluating virtual collaborative efforts. There is a lack of consistency around what is being evaluated and how it is being measured.

A variety of instruments in use show widely differing characteristics in theoretical orientations, units of analysis, levels of details, categories of analysis, and discrimination of content (De Wever, Schellens, Valcke, & Van Keer, 2006; Strijbos, Martens, Prins, & Jochems, 2006). The different instruments or methodologies may or may not address contextual issues such as group composition, task features or task complexity, and whether or not roles were explicit or role orientation occurred. Researchers may evaluate collaboration based on density of the social network, numbers of messages, quality of communications variously defined, or group processes. Units of analysis and instruments for content analysis do not tend to be overtly discussed or justified within many of the studies, which often involve limited attention to formal measurement characteristics. This is not unexpected in an emerging field of measurement such as this, but does deserve additional exploration as the research area moves forward.

Among theoretical constructs, De Wever et al. (2006) analyzed 15 constructs currently in use and found that most did not mention inter-rater reliability, and only 33% explained their theoretical background. Strijbos et al. (2006) describe the methodology of research and evaluation in the field as lacking debate and critical reflection. Hence, the validity and reliability of generalized methods is not as yet fully established, and results of research must be screened for the evaluative framework before findings can be generalized across studies and situations. The emphasis on the types of content to be evaluated, the unit of analysis, and the theoretical grounding are various; proscriptions are vague; and the evaluative context may change between settings in order to be appropriately matched to the technology that is used in each setting (De Wever, et al., 2006; Strijbos et al., 2006). Rather than interpreting this as a barrier to work in this area, this dissertation study sees it as an opportunity for work that can contribute to the field, in an area very relevant to educational settings and interests around the work, as described in this introduction to this chapter.

Content analysis. The primary ways that virtual collaboration is evaluated are through content analysis or overall group performance. Content analysis is defined here as the examination of communication elements and processes to determine trends or phenomena present in the communication and the meaning or purpose served. Content may be analyzed quantitatively with the unit of analysis coded, summarized and frequency or percentages of coded types calculated; a qualitative analysis may involve case studies or participant observation to infer trends without computing frequencies (Strijbos et al., 2006).

Unit of analysis. Methods for content analysis differ with regard to the unit of analysis used. The unit can be messages, threads of successive joined messages, thematic units, complete discussions, paragraphs, illocutions or utterances, all of which are used by different researchers (Strijbos et al., 2006). According to Schellens, Van Keer & Valcke, (2005) the most widely used unit of analysis is complete messages, in no small part because the author of the message intended for what they wrote to be a complete unit. Discourse analysis will be discussed more thoroughly in Chapter II.

Social-Emotional Learning

While outside the scope of this dissertation project, it should be mentioned here that many of the foundational skills necessary for successful collaboration among students often can be categorized as social-emotional skills. Intrinsic motivation rated high for virtual collaborative work in a study by Rienties et al. (2008) and they found that the intrinsically motivated students also ranked high in social relatedness and perceived competency. Learning is a social process, and social-emotional skills not only contribute to but also are critical for enhancing academic success, with prosocial behavior of students linked to increased engagement and higher outcomes on achievement tests (Zins, Bloodsworth, Weissberg, & Wahlberg, 2006). The Collaborative for Academic, Social and Emotional Learning (CASEL) (2003) describes a set of social emotional learning constructs that are key to developing abilities in collaboration and other 21st century skills; they are listed in a table in Appendix O.

Professional Development for Collaboration in a Digital Environment

The intent of this study is to contribute to research that may inform practice for instructional and assessment strategies in this emerging area of collaboration in a digital environment. There may be links found between the trends identified in some of the digital student work and research literature regarding supporting student learning and teacher professional development in this emerging area. Although work product trends will be identified in the study (see Chapters 2 and 3), this literature survey now introduces some of the research base regarding professional development approaches for preparing teachers for the 21st century skills challenges. Guiding leadership in formulating instructional design, and ensuring teachers are well prepared to address the instructional needs will be an important part of supporting digital collaborative learning in K-12 education.

Teacher professional development and continuing support concentrated on pedagogical content is necessary to facilitate student-centered learning with a focus on higher order skills as characterized by 21st century frameworks (Inan et al., 2010). Incorporating 21st century skills such as computer-supported collaboration in K-12 education has been described as needing concerted effort on the part of systemic leadership. For instance, chief among tasks will be providing professional development opportunities for teachers in the field as well as insuring pre-service instruction from university partners. Rotherham and Willingham (2009) point out that methods for teaching 21st century skills such as self-direction, collaboration, creativity, and innovation are not yet well known or fully understood, but should be taught in the context of practice with feedback, and strategies for improving practice with benchmarks for achievement. As the methods for teaching many 21st century skills are not yet known, uncovering the implicit domains involved and discerning sub-skills that can be taught to support 21st century skills would be an significant contribution, and could lead to targeted professional development opportunities for educators to prepare for teaching such skills. In order to provide feedback for student growth, educators must themselves be proficient at the skills.

The need for teacher training and curriculum design in the areas of collaboration, technology and social emotional learning have been discussed roundly in the literature, both within the framework of 21st century skills as well as in these instructional areas outside of a 21st century focus (Barron & Darling-Hammond, 2008; Dede, 2005; Donovan et al., 1999; Harris et al., 2009; Inan et al., 2010; Lou et al., 2001; Rotherham & Willingham, 2009). As these general areas relate to the specific topic of this dissertation, technology and collaboration, literature on professional development and implications for instructional design in these areas is discussed in the following sections as a frame for Research Question 3 and possible implications from the results of this study.

Collaborative Learning

Collaborative learning has been identified as central to most 21st century frameworks (P21, 2008; Dede, 2010). Researchers cite teacher training and practice in cooperative learning strategies as essential to the success of the strategy in promoting student learning due to the challenges inherent in implementation of collaborative learning (Barron & Darling-Hammond, 2008; Lou et al., 2001). Aside from training in the pedagogy and techniques that support collaborative learning experiences, teachers must be able to model collaborative processes (Barron & Darling-Hammond, 2008). Moreover, instructional design must be attentive to scaffolding group processes and interactions, task development specific to collaborative group work, motivational supports, and formative feedback cycles (Barron & Darling-Hammond, 2008).

In a meta-analysis of cooperative learning research, Johnson, Johnson and Stanne (2000) present the last major models of cooperative learning as developed in the 1980's, and show research on use and effectiveness of cooperative learning models decreasing by 50% between the 1980's and the 1990's. Today's younger teachers may have experienced cooperative learning as students, and they may not have received training in cooperative learning during their teacher preparation program. Johnson, Johnson and Stanne cite the incorporation of many cooperative learning techniques throughout packaged curriculum, making the use of cooperative learning techniques fairly widespread, though the extent to which teachers are able to unpack scripted curriculum and use elements such as cooperative learning strategies in new or different curricular areas has not been assessed.

K-12 teaching is typically performed in a classroom environment with a high number of students paired to one teacher; a 32:1 ratio for middle school and high school is relatively standard, and in the current low budget climate, many secondary schools have a much higher ratio. Elementary schools vary from 30:1 in many early primary classrooms in Oregon, to 20:1 in California, which has class-size reduction funding for K-3rd grades. As such, teachers often work in isolation from peers, and have many responsibilities to meet in a short amount of time. Therefore, some teachers may lack opportunities to practice collaboration with other educators. The most common form of educator collaboration may be between regular education teachers and education specialists as they collaborate regarding individual student needs.

Academic Social-Emotional Learning

The social emotional learning (SEL) generalized core skills consist of self-awareness; social awareness; relationship skills; self-management; and responsible decision-making (CASEL, 2003). SEL skills are recognized as promoting both long and short-term positive outcomes for academic and personal success. These skills are aligned with collaborative learning skills such as personal responsibility; communication; group processing skills; decision-making; and conflict management and resolution (Barron & Darling-Hammond, 2008). For students to be successful in collaborative working environments, their social-emotional skills must be operative, and for students to be operative in social-emotional skills, their teachers must be teaching these skills as well as integrating the practice of these skills throughout the curriculum and school program.

Children higher in social-emotional skills are better able to manage emotion, establish healthy relationships, meet personal and social needs and make responsible and ethical decisions (Zins et al., 2006). Cohen (2006) describes the ability to listen to self and others, and be critical and reflective as precursors to communicating and collaborating; these skills are described as underlying responsible and caring participation in a democracy. Educating children in social emotional skills increases their relatedness in society and their ability as lifelong learners (CASEL, 2003; Cohen, 2006). Social emotional skills are often taught in isolation in developmental settings, such as listening skills for kindergarteners, but these skills can become integrated into curriculum and classroom processes as student s progress in grade levels (Cohen, 2006). Whereas Social Emotional learning offers precursory skill sets for great success in collaborative learning, so does collaborative learning offer continued practice and refinement of those skills so important for success as lifelong learners and participation in societal processes (Raggozino, Resnick, Utne-O'Brien, & Weissberg, 2003).

Several states have adopted standards for social-emotional learning and a Bill has been introduced to Congress. The Academic, Social, and Emotional Learning Act of 2011, HR 2437, is intended to increase support for teaching SEL skills in schools.

Professional development is necessary to provide teacher expertise in new pedagogies that support learning based on cognitive science (Pecheone & Kahl, 2010). Social-emotional learning, widely viewed as integral to cognitive based learning theories, is another domain that may not be widely taught to teachers, who must master core academic instructional skills such as reading and/or math concepts as a priority. School counselors, who once presented social-emotional skills to classrooms or small groups of students, have been downsized in recent difficult economic times, leaving the promotion of social-emotional skills to teachers over-burdened with concerns for achievement as measured by standardized test scores and curriculum driven by data on core skills such as reading and math.

Technology

The incorporation of technology across disciplines in K-12 education is central to the inclusion of 21st century skills in the curriculum. For teachers to incorporate technology in the curriculum, they must themselves be prepared to do so, and have some degree of fluency in technology themselves. Studies in K-12 education describe teacher applications of technology for instruction as lacking in breadth, depth, and variety as well as lacking integration with curriculum (Harris et al., 2009). Kleiman (2004) states that success in 21st century skills and technology integration depends on the preparation and support of teachers and appropriate curriculum design. Harris, Mishra and Khoeler insist that teachers must know the appropriate pedagogical strategies, including cognitive, social and developmental theories of learning, for various ages of students and content area instruction for meaningful integration of technology in K-12 programming.

The International Society for Technology in Education National Educational Technology Standards for Teachers (ISTE NETS*T) (ISTE, 2008) outlines five comprehensive standards with performance indicators for the incorporation of technology in schools:

- Facilitate and Inspire Student Learning and Creativity in both face-to-face and virtual environments
- Design and Develop Digital Age Learning Experiences and Assessments including digital tools and resources
- Model Digital Age Work and Learning demonstrating fluency in

technological tools for collaboration, communication and creative work

- Promote and Model Digital Citizenship and Responsibility
- Engage in Professional Growth and Leadership to continuously improve professional practices

For the full, comprehensively discussed ISTE NETS*T standards, see Appendix I.

NETS essential conditions. ISTE (2008) outlines several conditions that must be present at the school site in order for technology infused educational experiences work smoothly, and which require the support of instructional leadership and resource allocation. These conditions include but are not limited to:

- Implementation planning to infuse student learning with ICT and digital resources
- Equitable access to current and emerging technologies
- Skilled personnel able to select and effectively use ICT resources
- Ongoing professional learning and practice opportunities in technology
- Technical support
- Curriculum frameworks that support digital age learning and work;
- Student-centered learning to best meet student needs and abilities
- Assessment and evaluation of teaching, learning, the use of ICT and digital resources

See Appendix J for the full description of NETS Essential Conditions.

New Models of Professional Development

Education leaders cite curriculum, teacher expertise and assessment as the main challenges for the integration of 21st century skills in the schools, and suggest an long-term iterative process of planning, implementation, reflection and continued planning with implications for teacher training (Rotherham & Willingham, 2009). The effects of professional learning experiences that are intense and focused on the work of teaching appear to support the new paradigm of professional development (Wei, Darling-Hammond, Andree, Richardson, & Orphanos, 2009). The new model of professional development involves content area expertise, sustained over time, with application to learning and a focus on student learning and achievement. Teachers need time to develop knowledge in the content areas to effectively teach students matching the content (Gersten, Dimino, Jayanthi, Kim, & Santoro, 2010). For professional development to be truly effective, teachers must be able to participate collectively in ongoing learning that allows in-depth discussion of strategies and an opportunity to practice and receive feedback (Education Northwest, 2010). Professional learning communities fit these effectiveness standards, creating a culture of collaboration by being site or district-based, practice-oriented and having a sustained focus over time.

When professional learning communities are focused on student learning and achievement, students benefit through improved achievement scores over time. 30 to 100 hours of professional development spread out over six to 12 months have a positive effect on student achievement, whereas limited professional development from five to 14 hours total have no statistically significant effect on student achievement; an average of 49 hours of professional development in a year can boost student achievement by approximately 21 percentile points (Wei et al., 2009). The use of research, data interpretation, and application to student learning is imperative (Saunders, Goldenburg, & Gallimore, 2009; Monroe-Baillargeon & Shema, 2010; Vescio, Ross, & Adams, 2008).

In a controlled study on professional development, teachers who participated in a Teacher Study Group received support in looking at research in reading, debriefing previous applications of the research, looked at lessons on teaching reading for which the research was applied, and collaboratively planned lessons with their group. These teachers' knowledge of the content and their ability to deliver the content was significantly different from the control group. Student knowledge of the content based on test scores was also significant (Gersten et al., 2010). Students of teachers who participated in a professional development program experienced significantly larger gains in learning as measured by assessments than those students in the control group (Johnson & Fargo, 2010). Designing and promoting sustained high quality professional development opportunities for teaching collaboration in a digital environment will be central to the inclusion of this learning modality in the curriculum.

Performance Assessments for 21st Century Skills

Assessment and accountability-driven education systems call for valid and reliable assessments for standards and skills taught; schools need a way to assess student ability and measure growth in order to effectively plan, deliver and monitor instructional programs. Adequate measures have not been widely or uniformly developed to measure 21st century skills, which as discussed previously are cross-cutting in many of the higher order thinking skills in the U.S. new common core standards, and the standardized multiple-choice assessments currently in use for measuring student performance in content areas are not designed to consider 21st century skill sets (Darling-Hammond & Adamson, 2010). Traditional assessments can measure factual recall, vocabulary, basic reading comprehension and algorithmic procedures, but are often not adapted for assessing applied higher order thinking and synthesized skills (Baker, 2008). Assessment of 21st century skills must be sufficiently performance-based to capture analysis, reflection, collaboration, and using technology to respond to essential questions (McTighe & Seif, 2010). Through the development and validation of performance assessments for 21st century skills, the schools may be better able to include such skills as part of the curriculum and measure student and school progress in those areas.

Performance Assessments are generally defined as opportunities to construct an answer, produce, or perform; or to apply knowledge and skills without pre-determined options. A performance assessment can be a collection of performance tasks, defined as "a structured situation in which stimulus materials and a request for information or action are presented to an individual, who generates a response that can be rated for quality using explicit standards. The standards may apply to the final product or to the process of creating it" (Stecher, 2010, p.3).

The structured piece of this definition can help accommodate the need for standardization and replication, as without standardization an assessment can be less useful for comparison between students or schools, thereby rendering it ineffective for accountability purposes. While assessment experts and researchers are still working toward an entirely agreed upon definition of Performance Assessment, it is often defined in terms of what it is not—multiple choice exams containing solely factual or procedural level questions, not embedded in a context or activity (Pecheone & Kahl, 2010; Stecher, 2010). The more complex arenas in which performance assessments tend to take place therefore have generated such structured requirements as the Stecher definition discusses, when use includes replication or comparison purposes.

Performance assessments may take many forms, including portfolios, which are more difficult to replicate, to writing tasks scored by rubric, conducting or analyzing experiments, or synthesizing information from various sources to construct a response to a query in any discipline. It is typical for performance assessments to have a defined task with stimulus and outcomes that may be described as: relatively simple/relatively constrained; relatively simple/relatively open; relatively complex/relatively constrained; and relatively complex/relatively open (Stecher, 2010).

Kane, Crooks, and Cohen (1999) consider performance assessments to be more authentic and valid when they replicate the conditions under which adults would perform the same tasks. Computerized performance assessments would replicate many adult-oriented work environments and include authentic 21st century tasks. Multi-user virtual environments offer promising possibilities for assessing 21st century skills and may be cost effective as well as allowing tracking of interaction and collaboration, but they have not yet been scaled for use with large populations outside of the gaming industry (Silva, 2008).

Performance assessments across areas that are construct-referenced to the same 21st century skills may be considered a good form of measurement for these abilities due to the tests focusing on the construct-measured ability and not only the specific domain of knowledge and skills supporting it, if constructs fall across domains (Messick, 1984).

Some achievement constructs measure declarative and procedural knowledge, with a student score showing their status in that domain (Baker, 2008). In contrast, a performance assessment would be more likely include opportunities for students to demonstrate strategic and schematic knowledge as well as declarative and procedural skills. An achievement construct of cognitive ability often represents a domain of complex tasks, referred to as fluid, developing or learned abilities; these cognitive abilities involve contextualized mental models and complex performance with multiple ways to be represented (Haladyna & Downing, 2004).

Barriers to the Implementation of Performance Assessments

Sometimes significant investments are required to implement performance assessments with regards to financial expenditures, timeframe for administration and evaluation, coordinating organizational processes for administration and scoring, and the training of staff system wide (Baker, 2008; Linn, 2008). Traditional multiple-choice assessments are conveniently uniform and scored automatically, and have been quoted as costing about $1-10 per student in 2003 as compared to performance assessments such as the College Work Readiness Assessment (CRWA) at over $40 per student plus an estimated $8,000 in staff training per student enrolled (Silva, 2008).

Designing performance assessments is at times more complicated than designing multiple choice measures, although it should be kept in mind that the quality control, item bank development and psychometric processes involved with selected response measures can be quite expensive as well. For performance assessment, task creation, including alignment of complex tasks to standards, is called for, as well as scoring options and designing scorable products; and creating a system for scoring accuracy require intensive, coordinated development over time as often these systems are not yet readily in place (Pecheone & Kahl, 2010). Other barriers include reliability; equating; and uniform scaling, which is associated with a reduced emphasis on simplified total-score quantitative outcomes and requires more time-consuming scale-oriented validation (Balistreri, et al., 2011; Silva, 2008).

The next chapter introduces the methodology for this study. It describes a series of phases of discovery and analysis intended to address the research questions introduced in this chapter.

CHAPTER II

METHODS

This study of student performance on a computer-based assessment of digital literacy had six phases of research that inter-relate or build upon each other; Table 6 outlines the phases and their relationship with the research questions in Chapter I. Each phase has specific iterative processes that will be discussed in detail in ensuing sections.

Table 6
Phases of Research

Research Question	Phase	Purpose
RQ1a	Phase 1: Review and initial coding of student work samples	Develop a taxonomy reflecting student work patterns seen through an initial review of student work
RQ1a	Phase 2: Develop initial rubric	Structure the taxonomy into a scoring rubric
RQ1a RQ2	Phase 3: Assess student work and evaluate rubric	Explore inter-rater use of the rubric and teacher reflection regarding the rubric
RQ1b RQ2	Phase 4: Examine in-depth categorical patterns and trends in student work	Explore in-depth attributes of collaboration and non-collaboration displayed in student work, using the rubric and scored work to explore trends
RQ3	Phase 5: Examine skill areas for instructional design	Identify sub-skills through Phases 1-4 that could be instructed to improve student collaboration skills on task
Not associated with a RQ	Phase 6: Explore professional development needs	From an instructional leadership stance, explore implications of identified sub-skills relative to teacher professional development needs for supporting 21st century skill development in this area

Design

A descriptive, cross-case analysis design that integrated mixed methods was used to evaluate student performance to address the research questions, through the six phases. Greene, Kreider, and Mayer (2005) described mixed methods as, "…approaches to social inquiry [involving] the planned use of two or more different kinds of data gathering and analysis techniques, and more rarely different kinds of inquiry designs within the same study or project" (p. 274).

The basic assumption of mixed designs is that there are multiple legitimate approaches to research in the social sciences, and that the complex diversity of using multiple lenses to examine research questions can offer a deeper understanding. Greene (2007) identified five purposes for mixing methods—triangulation, complementarity, development, initiation, and expansion. Triangulation, for instance, can increase reliability and validity, serve to control bias, and offer multiple perceptions about a single reality (Golafshani, 2003).

Caracelli and Greene (1997) describe mixed methods research designs as falling into two categories: component designs or integrated designs. Component designs are methodologically discrete, where the methodologies are not mixed but combined only at the level of interpretation; integrated designs integrate the methods and elements of the different paradigms.

An integrated design is used here, drawing on extracting both qualitative and some quantitative information from the same work products. For this project, analysis of digital notebooks for Research Question 1 — which addresses whether the use of the artifact Arctic Trek collaborative Notebook falls into distinct patterns — involved qualitative methods through the Body of Work method (see below). Once trends were identified, Research Question 2 — the relationship of Notebook patterns with age — involved quantitative reasoning through frequency counts, summary numbers and displays grouping rubric-related traits into results based on the age variable. Cognitive Task Analysis and Backward Design were employed to examine skill areas for instructional design to address Research Question 3.

The qualitative methodology to address the first research question is explored first in the next section. Qualitative approaches can be useful when the research seeks to describe an aspect of the participant or participant's work, and generate information about participants' traits, experiences, attitudes or beliefs. Qualitative methods are sometimes favored to quantitative methods when relevant variables have yet to be identified and an exploratory phase of research is undertaken (Marshall & Rossman, 1995). Qualitative analysis involves interplay between the data and developing conceptualizations, from which theory may emerge. The researcher suspends tacit theory and keeps focus questions as broad as possible so that data can be examined with an openness that allows themes to emerge that may not have been previously conceptualized by the researcher. Savenye and Robinson (1995) suggest the use of qualitative methods for researching the use of educational technology as it can look at what is occurring as students use a new technology.

Cross-Case Analysis

This study used case-oriented strategies for qualitative cross-case analysis, with each Notebook treated as a case. Case-oriented strategies for cross-case analysis can be suited to answering the research questions about the identification of categorical patterns of skill development. Here patterns will focus on possible types of performance in collaboration in a digital environment among student groups.

Overview of methodology for case-oriented strategies. In general, Cross-Case Analysis is a method used to support qualitative research in complex settings through the examination of events, traits or processes across a number of cases in order to increase generalizability through seeing "…processes and outcomes across many cases, to understand how they are qualified by local conditions and thus to develop more sophisticated descriptions and more powerful explanations" (Miles & Huberman, 1994, p.172). Cross-case analysis allows a researcher to discern whether the findings within a specific case make sense beyond that case, and examine similarities and differences across cases to discover a broader understanding of or explanation for the phenomena observed and the conditions that may support the phenomena.

Qualitative cross-case analysis can be either variable-oriented or case-oriented. This study uses case orientation for the qualitative phase, followed by a variable orientation to order the cases in the more quantitative phase. This is followed by phases of examining the evidence for instructional design and instructional leadership implications, based on the trends identified for the data set. It should be noted this is a limited data set and a small number of "case" related digital artifacts, thus the trend findings are exploratory and intended to lead to further studies in this emerging area of 21st century skill development.

The case-oriented approach used here is iterative and requires first examining each case as a unit, looking at arrangements and relationships within the case before investigating similarities across cases. The Notebooks were analyzed using two different case-oriented strategies; synthesis of multiple exemplars and forming clustered types or families. Miles and Huberman (1994) describe synthesis of multiple exemplars as collecting multiple cases reflecting a phenomenon, in this instance a computer-supported collaboration task performed by same-aged student groups, and examining the cases for essential elements, which are then used to illustrate the generalized findings across the group of cases.

Identifying commonality across cases involves looking for patterns of the phenomena among cases and then sorting the cases into groups sharing displayed patterns or configurations of the phenomena (Miles & Huberman, 1994), which may then be considered representative types for classification. Cases can be sorted by type, or ordered by the presence of an element. As the cases in this study were all structured similarly and clearly bounded by the parameters of the assessment task, as described in upcoming sections, they seemed well suited to case-oriented cross-case analysis through the identification of types, especially if the typology would then allow exploration for possible approaches to instructional intervention and professional development through connections with the research literature.

Sample

The sample for this study included students of ages 11, 13, and 15 years from schools in three different countries, the United States, Singapore and Australia. Teachers were recruited by ministries of education and National Project Managers in each country, with human subjects permissions as specified within each country. Data sets were provided de-identified for secondary data analysis. The IRB approval by the University of Oregon for secondary data analysis of de-identified data specified use of code number for students, without names or key. Participation was voluntary for both students and teachers.

Sampling Procedure

Schools were identified by their national ministries or departments of education through professional education networks in the participating countries. The samples were not representative country samples and were not intended to reflect an indicator of national performance. Rather, the intent of the data collection was to see demonstrations of performance to interpret how the instruments performed and what overall patterns might be seen. Schools or districts were selected by their ministries of education that were deemed capable of meeting the technical requirements listed in the task descriptions, such as sufficient computers and Internet capacity. ATC21S also requested that countries recruit a range of students expected to be lower performing, middle-range performing and higher performing in digital literacy, to offer a range of results.

Student Characteristics

Thirty-three notebooks (cases) were provided in the data set analyzed here, with approximately 100 students using the notebooks. Descriptions of the sample show in the Results chapter. Students were grouped in age-based groups in teams of three or four persons for the Arctic Trek assessment, which will be described in detail below. Teams of four were specified for the task but classroom configurations influenced the creation of smaller teams of three in some schools. The work was synchronous, with each student working from a different computer station but with teammates working together across multiple computers at the same time. Students were teamed with others from within their same classroom or school site for this task.

Sample Assessment Frame: ATC21S Cognitive Labs and Pilot Trials

The Arctic Trek Assessment trials were designed to measure ICT literacy and collaborative problem solving, with the use of social networking media to collaborate in a problem space. The full Arctic Trek task, only one part of which is analyzed here, consisted of several work products generated by students over a 45-minute period, one of which was the Notebook product described below, which is the focus of this dissertation research.

The full task, including the Notebook as only one part, was designed along with two other 21st century assessment scenarios to assess the development of skills from two of the ATC21S framework areas:

- Ways of Working: communication and collaboration (or teamwork).
- Tools for Working: information literacy and ICT literacy

Overall, the ATC21S model groups ten 21st century skills into four areas: ways of thinking, ways of working, tools for working, and living in the world. Two of these areas that are incorporated in the Arctic Trek task are described in more detail below.

Tools for Working

As described by ATC21S, Tools for Working within the Notebook task encompass two separate but related skills areas and roles or manners of functioning in digital environments: Consumer and Producer. These functional roles mimic authentic roles for career- and college-readiness, in the workplace, and in digital environments in society at large.

Consumer. Functioning as a Consumer involves obtaining, managing and utilizing information or knowledge from shared digital resources and experts.

Producer. Functioning as a Producer involves creating, developing, and organizing information or knowledge in order to contribute to shared digital resources. Functioning as a Consumer of digital resources builds to functioning as a Producer of the digital resources.

Ways of Working

The ATC21S project defines the 21st century area Ways of Working involved in the Notebook task as the skill sets of Social Capital and Intellectual Capital. These skill areas include participating, contributing and eventually initiating and taking a leadership role in facilitating social networks, as well as working collectively with others to create shared intellectual knowledge.

Social Capital. Developing and sustaining Social Capital (SC) in this context involves using, developing, moderating, leading and brokering the connections within and between social groups in order to facilitate collaborative action for learning.

Intellectual Capital. Developing and sustaining Intellectual Capital (IC) through social networks in this context involves understanding how tools, media and social networks operate; and using these tools, techniques and resources to build collective intelligence and integrate new insights into personal understandings. Intellectual Capital is a culminating construct that reflects the use of skills from the Consumer, Producer and Social Capital constructs.

Multiple Opportunities to Demonstrate Skills

The intention of the full set of three ICT literacy demonstration tasks for ATC21S was to embed skills described above into three different learning contexts: a math/science context through the Arctic Trek task, a English language arts task through a digital graphic organizer literature analysis task, and a second language acquisition task through a chat tool with students co-constructing knowledge in a second language.

Methodologically, the full set of tasks, which are beyond the scope of this dissertation, build an argument for validity and reliability through a sampling design of student performance over the three contexts, and students are given opportunities to participate in multiple groups or teams. Together, the three scenarios and multiple team placements are intended to paint a picture of student proficiency as learners in digital communities (Wilson et al., 2012).

The other two contexts are out of the scope of this dissertation, as are all the other work products and student assessments embedded in the Arctic Trek task. Therefore this dissertation focuses only on the collaborative notebook work product in the Arctic Trek task, which is insufficient on its own for inferences about individual student work. However it should be noted that the full assessment process itself ranged for students over several scenarios and team placements. In this way the assessments are a form of "saturation evaluation," where the intention of each additional task and team placement is to "saturate" the information available on the individual student as a learner in digital networks, looking for the replication of patterns typical for that student in digital interactions over multiple contexts and teams.

This would be similar to a student using integrated technology over multiple courses or periods of the school day, or across several subject matter areas, none of which focused exclusively on learning *about* technology but all of which may have a signature of learning *with* technology.

ATC21S Scenario 2: "Global Collaboration Contest: Arctic Trek"

This section describes the full Arctic Trek task, to give the reader sufficient information to understand the role of the Notebook artifact, which will be explored in the Results chapter.

The full Arctic Trek is a 45-minute computer-based performance assessment, administered to students in a team format. Students engage in an interactive web search/web quest exercise of seeking information, or "information foraging" online, to solve clues and answer questions in order to demonstrate their ability with technology and collaboration. The information foraging activities draw on a set of real scientific documents from a science expedition to the polar region (http://polarhusky.com, 2005).

The background on the development of "Global Collaboration Contest: Arctic Trek" assessment scenario is discussed by Wilson and Scalise (2012), contributors to the assessment design:

> For the ATC21S project, the Berkeley Evaluation and Assessment Research (BEAR) Center at UC Berkeley and the University of Oregon developed three scenarios in which to place tasks and questions that could be used as items to indicate where a student might be placed in the collaborative digital literacy construct. Each scenario was designed to address more than one strand, but there were different emphases in how the strands area represented among the scenarios. Where possible, we took advantage of existing web-based tools for instructional development. The Arctic Trek task is described below.
>
> *Arctic Trek.* One potential mechanism for the assessment of student ability in the learning network aspect of ICT literacy is to model assessment practice through a set of exemplary classroom materials. The module that has been developed is based on the Go North/Polar Husky information website (www.polarhusky.com) run by the University of Minnesota. The Go North website is an online adventure learning project based around arctic environmental expeditions. The website is a learning hub with a broad range of information and many different mechanisms to support networking with students, teachers and experts. ICT literacy resources developed relating to this module focus mainly on the

> Functioning as a Consumer in Networks strand. The tour through the site for the ATC21S demonstration scenario is conceived as a "collaboration contest," or virtual treasure hunt. The Arctic Trek scenario views social networks through ICT as an aggregation of different tools, resources and people that together build community in areas of interest. In this task, students in small teams ponder tools and approaches to unravel clues through the Go North site, via touring scientific and mathematics expeditions of actual scientists. The task helps model for teachers how to integrate technology across different subjects. It also shows how the Go North site focuses on space to represent oneself, and can be combined with tools that utilize texting, chat and dialogue as forms of ICT literacy. (Wilson & Scalise, 2012, p. 5)

The goal of the assessment was for students to work together with their team in a contest-like format, searching to find the answers to all of the clues they encountered on the "journey through the Arctic" with the Notebook being the collaborative workspace.

Skills used in the Arctic Trek assessment context included basic math and science skills such as reading graphs and charts; performing simple calculations and map reading; and reading comprehension skills for analysis of content. Recall that a broad range of such skills were intended to be embedded over the three ATC21S scenarios, as a sampling design for the *context* of the assessment to represent typical situations encountered in schools. The actual *constructs* of interest for measurement were such skills as computer use including online tools; web navigation; and collaboration *within* a range of such digital environments, or in other words, digital skill and collaboration emplaced in a range of knowledge-rich and team settings.

When each student logged into their computer for the Arctic Trek task, they were assigned a number (ex: 144), and the only means of communication available to collaboratively solve the clues and enter their team response information was through the Notebook to be examined here, which was a shared document. It is described fully in the section “***Shared Document Notebook***” below, with example Notebooks included in Appendices H and I.

In order to access the collaborative tools, students had to find the link to the shared document Notebook, and enter the document space to share the information they found, seek or receive help, and to decide on team answers. Student performance in all these activities was tracked. The opening screen of Arctic Trek is shown in Figure 2.

When students entered the Arctic Trek, after having an opportunity to set up their Notebook, they had an opportunity to work with their team to assign roles and tasks by sorting task and role cards on the screen through mouse manipulation, as shown in the screen shot shown in Figure 3.

Original slide 41, the Arctic Trek opening page:

Figure 2. Opening Screen Shot for Arctic Trek Assessment.

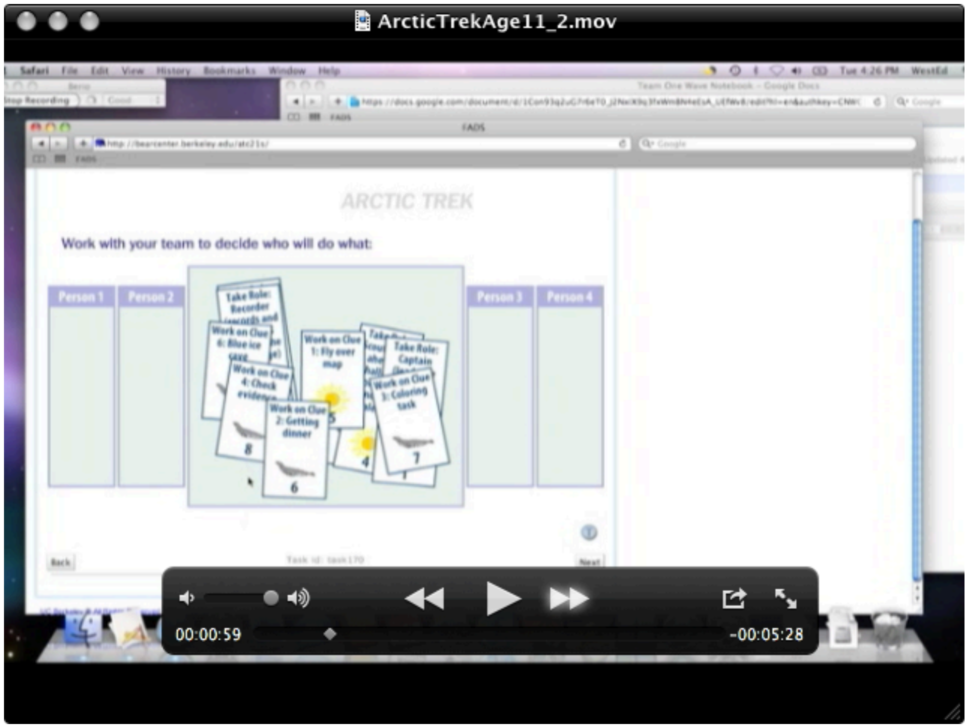


Figure 3. Screen Shot from Arctic Trek Assessment: Assigning Roles and Tasks.

Students were to use the Notebook to decide which team members should be Persons 1, 2, 3 and 4, and which role and tasks would be assigned to whom. Then, as students carried out their tasks, they were to report to each other through the Notebook, compare answers, seek help, or track group progress.

Each clue had an associated web page made available in the task, with assorted links that might lead to further information to assist students in solving the questions associated with the clue. The clues often involved reading background information related to the clue, or doing interactive exercises to help answer the clue.

The following page of the assessment, as shown in Figure 4, illustrates the prompt for Clue 2 and scaffolding for the information search. The prompt reads " The first sentence of the clue helps you select a webpage from the list at the right. Which page is about what land animals eat? Click on that link and search for the answer to that question." Here, the student is prompted to choose the link titled "Land Animal Food" and would read further information at the site to help them answer the clue. They could check their ideas or share their information with their teammates through the team Notebook; this screen shot also shows the Notebook open in the window behind the clue, with student use of the Notebook. Note that the screenshot is in low resolution as an actual screen image of student work from the trials, where screen recording was occurring throughout the task.

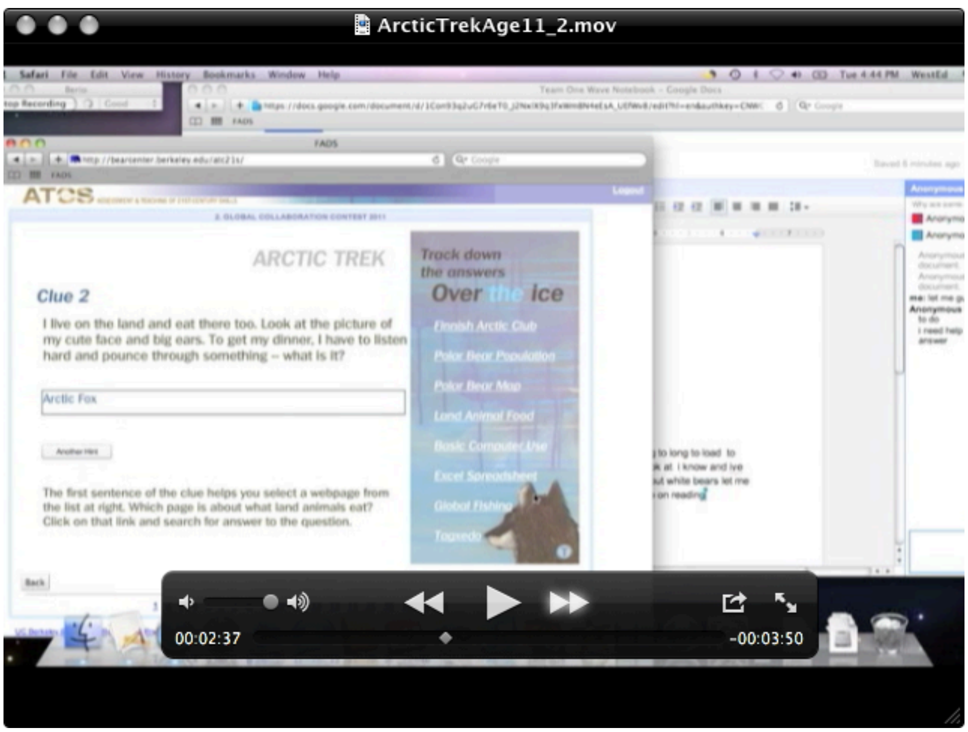


Figure 4. Screen Shot of Clue Two for the Arctic Trek Assessment. This student view shows the structure of a clue with prompts below, and live links on the right.

As students navigated through the clues on their Arctic journey, they performed a variety of math/science tasks. Answering one clue includes an exercise that involves transferring polar bear cub and mother population ratio data from a graph to a probability spinner, as shown in the screen shot below. The student working in the screen shot in Figure 5 has their Notebook open in the window behind the spinner window, perhaps ready to report the colors and names they used to make their spinner. This is an assessment of creating a digital tool.

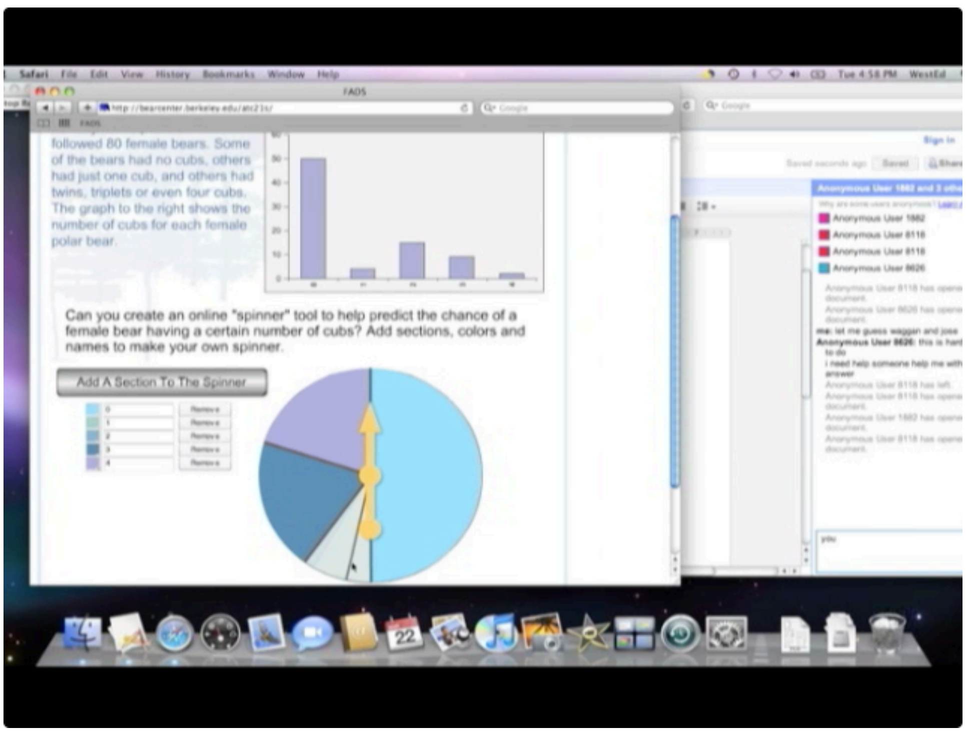


Figure 5. Screen Shot from Arctic Trek: Polar Bear Population Probability Task.

Another clue involves interpreting polar bear population data and manipulating an interactive graph to create a line for the graph that best matches the data. Students were to answer two questions regarding the process they used and the product they created in this exercise, as shown in the screen shot in Figure 6.

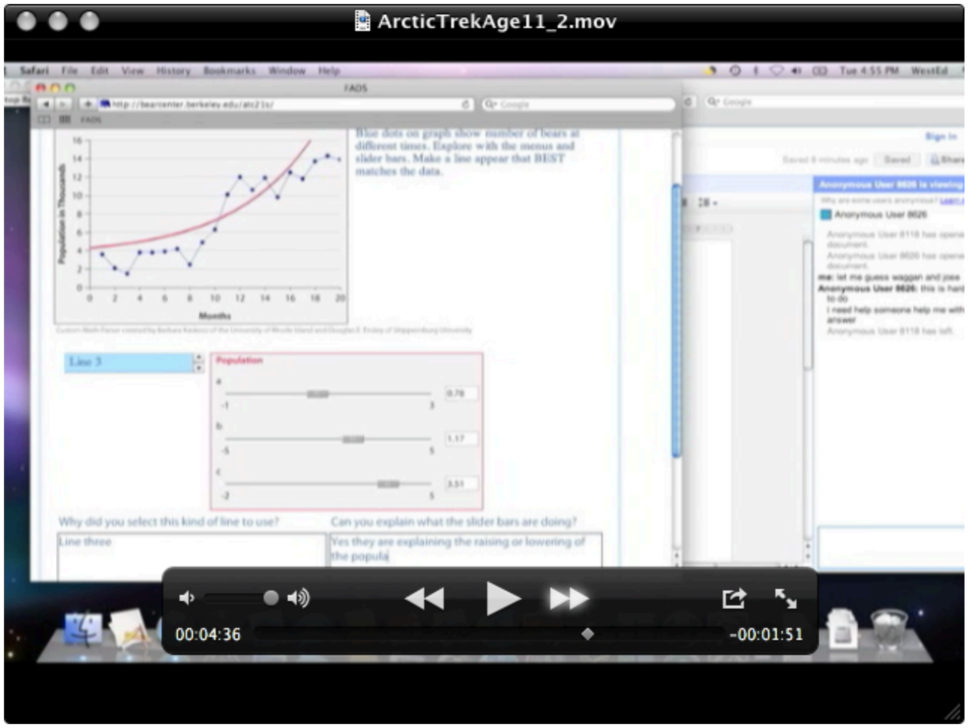


Figure 6. Screen Shot from Arctic Trek: Creating a Population Graph

For the full Arctic Trek task, Web 2.0 tools utilized in the assessment included additional tools besides the Notebook, which was a Google document. These other tools are outside the scope of this dissertation.

Notebook Specifics

The shared document in the assessment was called a Notebook and was a Google document set up for student use. As described previously, the purpose of the Notebook was to provide a collaborative space for students to identify themselves; organize their work processes by giving them a space to collaborate on choosing roles, assigning tasks, and tracking progress; sharing content material and resources; and negotiating clue answers so the team members could discern accurate responses to prompts and each have the information to enter in their separate answer spaces within the assessment.

The student work product “Notebook” was accessed by students from an opening page that prompted them to access the Notebook to “share ideas and coordinate using your team Notebook”, see the screen shot featured in Figure 7. Once students opened

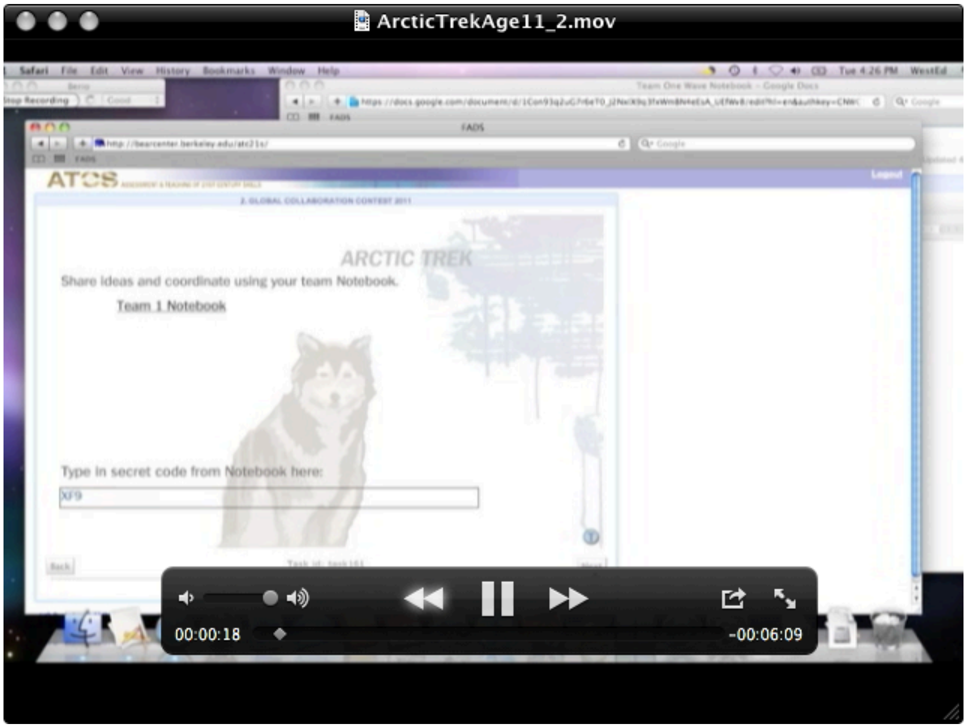


*Figure 7***.** Screen Shot from Arctic Trek: Notebook Link

their Notebook they were prompted by these Notebook instructions; as shown in the screen shot in Figure 8:

Team 32: Type or paste information here for your whole team to see. Use the menus above to format your text or highlight it with notes. To add pictures or to insert web addresses to other sites, use the Insert menu. Feel free to experiment with this tool! You can always delete parts and start over.

Your team's SECRET CODE: DF5

*Figure 8***.** Notebook instructions from Arctic Trek assessment Notebook. This is what the team sees when they open their Notebook. Each Team has a number and a secret code.

Students used their Notebook to report on the clues they answered, dialogue about possible answers, or ask for help, among other discourse. An example of a Notebook in progress is shown in Figure 9. The text students have written reads as follows:

Ok so im waiting for the map to load wt about you guys? me two it taking to long to load to hard to find im looking at all the stuff and its hard to look. a lot of stuff to look at I know and ive been looking at the same thing over and over again but it says nothing about white bears let me know if you find the answer i don't know the answer ether and going to keep reading
Found it it was the Laptev Sea and the next was Arctic Fox
My answer was 5 colors. where did u get tht answer from never mind I know how u got that answer jaime here is anybody else there
You need help how do you rate ur team
So you put the rate first and then you go up and put the other answer after
i don't get it it is really hard to do this this is jose
jaime do you get it this is jose ya wat do you need help on
ay do get what are tring to do here
waagan in onwho is jamie that's not how u spell my name wagaan is the way jose spelled it
Dominic is Anonymous user 1881
Yea so any way we need to fin this what slide you guys on and 8118 stop fooling around were nt fooling around whoever this is

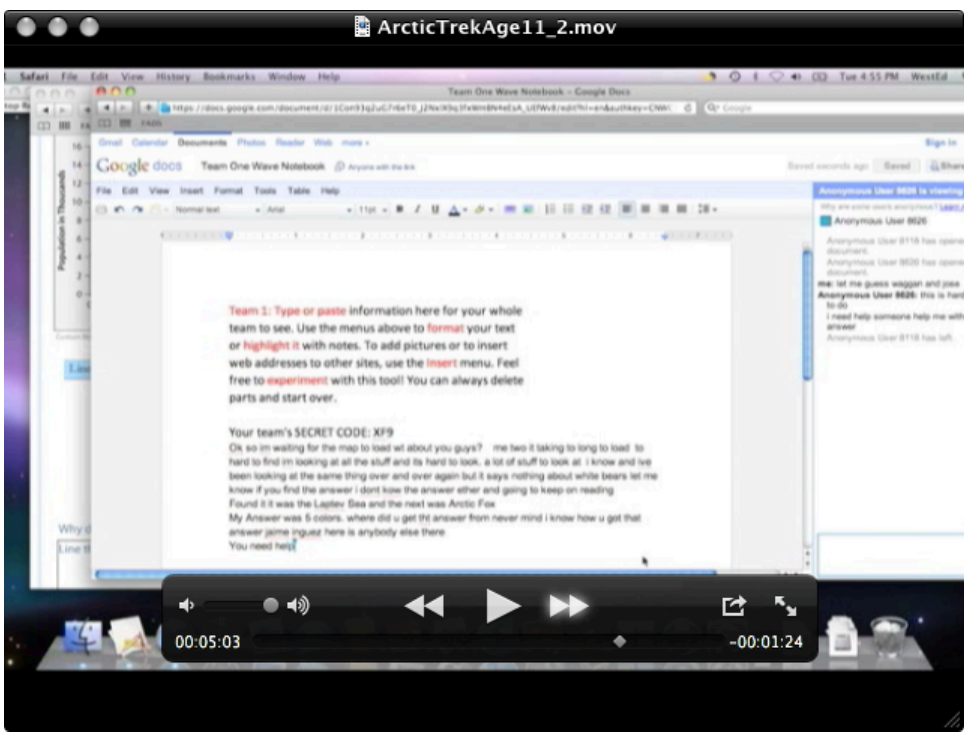


Figure 9. Screen Shot from Arctic Trek: Notebook Use During Assessment.

In the example shown in Figure 9, the Notebook is open in one window and a population graph task is open behind. The student writing in the Notebook is asking if the prior contributor needs help. Students could go back and forth between the Notebook and the various assessment tasks, with the Notebook being the continuous connection between group members. Two samples of the Notebook product are appended to this paper; one high scoring sample and one lower scoring sample, see Appendix H and I.

Further discussion of student work in the Notebook is discussed in the Results chapter. Examples are given here only for clarity regarding the task methodology.

Assessment Administration Instructions

Administration of the assessments was conducted was classroom teachers. They engaged in a training session in advance provided by their national country project managers, regarding the assessment purpose and process of the full range of tasks, outside of the scope of this dissertation. A standardized assessment delivery booklet, the Pilot Test Administration Booklet, was provided to the teachers, a section of which shows below, and teachers were guided through instructions on how to use it.

As with most assessments, teachers were present primarily to proctor and not provide content or process support. Teachers were instructed not to give help immediately even if the students had difficulty accessing the shared document or links as these were part of the digital literacy assessment. However the administration instructions did allow teachers to intervene and assist a student if the student had exhausted the three available resources for students, see instructions excerpted from the Pilot Test Administration Booklet, shown in Figure 10. In this case, teachers had a pop-up screen available for each student where any assistance provided could be described and included in the assessment record. Teacher assistance provided was then included in the assessment evidence collected for the student. The full Pilot Test Booklet with assessment delivery instructions is shown in Appendix L.

In about 5 MINUTES, give students "ASK THREE THEN ME" directions. Every student is expected to explore three sources of information before asking instructor or test administrator help. These three are: (1) task directions and resources on each screen, (2) questions online of team members to get and give help, and (3) access internet for information PRIOR to requesting help. Instructor help is to be RARELY given (see below for instructions on how), and students are to explore and do their best with the information and team members available. Instruct students that collaborating and using the Internet is expected and is NOT cheating for this assessment.

SAY:

"I will provide you with ASK THREE THEN ME directions. Every student is expected to use three sources of information before asking for help. First, you are expected to use task directions and resources on each screen. Second, work with your team members to get and give help. Third, use the internet for information. PLEASE KEEP IN MIND THAT THIS IS NOT CHEATING. Otherwise, you should explore the tasks and do the best you can with the information and team members provided. You are being assessed on YOUR ABILITY to work with tools and people online."

Figure 10. Sample Assessment Instructions from Arctic Trek Assessment.

Implementation of Phases

Each of the six phases of the dissertation analysis represents categorical components of the active investigative process associated with the research questions. The phases are iterative, as the data are analyzed in multiple ways and stages to address the research questions. The phases are described here, and summarized in Table 10.

Phase 1: Review and Coding of Student Work Samples

Phase 1 of the research in this dissertation project involved a concentrated qualitative analysis of Notebook cases utilizing a Body of Work method and Discourse

Analysis, explained below, in order to address Research Question 1a. These approaches examined the data and exposed as many as possible of the components of student ability and behavior displayed through the work product examined.

Body of work method. The Body of Work method was introduced in research for the purpose of setting performance standards on complex assessments such as constructed response, work samples, portfolios and combination formats (Cizek & Bunch, 2007). The Body of Work method has been used extensively by state departments of education to develop rubrics and set performance standards. The full method involves range finding, pinpointing important patterns and trends, and analysis with logistic regression. This study used the method iteratively as the qualitative technique for examination of the Notebooks, and employed the range finding and pinpointing processes.

Using the Body of Work method, the Notebooks were arranged from low to high for display of collaboration leading to task completion, and coded for where they fell in a proficiency category. Components of student behaviors generated in the body of work through display in the samples were listed on a working checklist along with elements that were expected to be present as per student instructions for the assessment task. The checklist was used as a means to track elements displayed both within and across Notebook samples, and used as one basis for generating the rubric. Student behaviors listed included both structural and content-based behaviors, with structural meaning such items as introductions, role and task assignment, or visual organization of the Notebook space, and content-based meaning sharing information to help answer clues, reporting progress, seeking help, or evaluating a team members answers or ideas. Results are discussed in the next chapter.

Discourse analysis. In order to determine the types of student abilities displayed in collaboration, it was necessary to understand the content that students created in the Notebook product, with the ultimate goal of analyzing their content for collaborative elements. Discourse analysis as a process looks at all discourse acts and makes no preconceived judgment about the value. Once discourse acts are coded, then the process is to review coded elements to look for categorical patterns, response or thread development, and develop a picture of the group discursive interaction.

Content analysis often involves collecting qualitative data about levels of participation as well as uncovering the variance among groups and situations so as to solidify instructional and programmatic practices to (a) enhance virtual collaboration as a tool for education, innovation and problem solving; and (b) better understand the psycho-social processes occurring in the problem solving space or with joint construction of knowledge.

Communication can be categorized as reactive, when responses occur in separate episodes but do not build on previous messages; or reciprocal, when messages co-occur across episodes and do build on previous messages (Strijbos et al., 2004a). Content analysis of discourse has been defined as including, but not limited to, the following categories displayed in Table 7.

Table 7

Discourse Analysis Sample Array of Categories

Categories	Study
Proposals or bids; questioning; building common ground; maintaining a joint problem space; establishing intersubjective meanings; positioning actors in roles; and constructing knowledge collaboratively to solving problems together	Stahl (2009)
New facts; students' own experiences and opinions; theoretical ideas, explication and evaluation	Schellens, & Valcke (2005)
Theory: theory, new point or question, experience, suggestion, and comments or Discussions: higher-level, progressive and lower level	Jarvela & Hakkinen (2002)
Number of members; density and intensity; responsiveness; and attentiveness of members	Fahy (2001)
Planning; technical; social; nonsense or unrelated	Veerman & Veldhuis-Diermanse (2001)
Affective; interactive; and cohesive	Rourke, Anderson, Garrison, & Archer (1999)
Participative; social; interactive; cognitive and metacognitive	Henri (1992)

Other methods or categories used for analyzing discourse include processes of knowledge construction and interactional dynamics through the study of purpose of discourse. Gunawardena, Lowe and Anderson (1997) used a grounded theory approach to develop a scheme for content analysis involving five phases of knowledge construction:

1. Sharing or comparing information
2. Dissonance or inconsistency

3. Negotiating agreements or co-construction
4. Testing tentative constructions
5. Statement or application of newly constructed knowledge

Ideally groups will attain the higher phases of communication. A meta-analysis of discourse using Gunawardena's content analysis approach showed that Phases 1 and 3 of knowledge construction tend to be dominant, while the Phases 2, 4, and 5 of knowledge construction occurred less often in the discourse (Schellens & Valcke, 2005).

Evans, Feenstra, Ryon, and McNeill (2011) have created a multimodal analysis with a theoretical framework to study interactional dynamics using co-references to track focus, dominance and coalition building. References are categorized using three levels of discourse: object-, para-, and meta-level co-references. They look for co-referential chains, or topics, to emerge. The unit of analysis is at the level of utterance. They note periods of high productivity and also for patterns of leadership, power, experience or confidence evident.

Researchers have used different units for analysis of discourse including messages, threads of joined messages, paragraphs, or utterances, with messages being perhaps the most widely used (Schellens & Valcke, 2005; Strijbos et al., 2006). Coding strategies vary with the unit and the theoretical orientation. Message units mean that compound sentences can be divided by the content, and that level of analysis affects the number of units coded and may be involved in unit overlap. Problems with coding messages in complete sentence form as a single unit of analysis include that some students will submit two messages within one sentence, such as a bid for new action and a reaction to a previous bid or comment from another student (Schellens & Valcke, 2005).

In this study, the unit of discourse analysis was fragment or utterance, and included any discourse act; even non-verbal acts such as a lone exclamation point or emoticon. A response to an utterance was coded as a response of just one reply, or a thread, if there were ensuing co-references to a topic. Some utterances were non-verbal, such as emoticons, but are expressive nonetheless, and were thus retained in the discourse analysis. All fragments or utterances were coded, whether they were on task or off task. See sample coding on Notebooks 2 and 8 in Appendix M, which will be discussed in detail in the next chapter.

The combined methods of Body of Work, Discourse Analysis and multiple exemplars for cross-case analysis provided the techniques of data reduction from the data set to use for exploration and categorization of elements. Traits were coded and a checklist was developed of traits and qualities displayed to track occurrences within and across cases to quantify how often traits, qualities or type of discourse appears throughout total work samples. The checklist is described in the Results chapter, as it was a result or outcome of the methodology here. A frequency count helped to describe the amount of evidence per code or trait, and helped to assess commonality of displayed traits across cases. Traits were analyzed and defined for the purpose of creating categorical groupings in Phase 1 of this study.

Phase 2: Rubric Development

The coded traits, qualities and behaviors developed through the Body of Work, discourse analysis, and cross-case analysis in Phase 1 were used in the development of a rubric that was intended to capture student ability in computer-supported collaboration such as this. This effort utilized iterative review and revision of the initial rubric. The rubric developed through this process was used to address Research Questions 1a and 1b.

Emerging rubric development. A second stage of the Body of Work method was used to separate coded Checklist traits designated explicitly as assessment tasks in Arctic Trek instructions (ex: "choose a role") from other traits or qualities identified in discourse analysis and cross-case analysis. A trait category was developed from the constellation of displayed activity that supported or facilitated performing the explicit assessment tasks.

Expert review. An educator from the field and the author used an emerging Six Traits Rubric with two student work samples to determine the adequacy of capturing student ability in collaboration in a digital environment. Adjustments were made to better reflect coded traits discovered through qualitative analysis.

Range finding. Student work sample Notebooks were sorted by level of assessment task completion, and the range finding of evidence of assessment task completion was initially established. Checklist qualities were assessed against task completion on each student work sample; as some qualities do not appear related to task completion, these are left on checklist and not added into rubric.

Second-Stage rubric development. The results of the above iterations of Phase Two were used to identify six traits that represent components of assessment task and four skill levels of displayed evidence. Task definition originated with the ATC21S Arctic Trek performance assessment authors, using 21st Century skills frameworks researched from the field. The initial Six Trait Digital Collaboration Rubric, described in the Results section as an outcome of the work, was developed for use.

Expert review. The initial Six Traits rubric was reviewed by an educator in the field and used by the author and educator in separate assessment of student work samples utilizing this initial version of the rubric.

Third-Stage rubric development. Following the expert review, the rubric was revised to become more sensitive to domains of collaborative work in order to better capture student ability in collaboration in a digital environment. The resulting revised rubric split the six traits into two dimensions: collaborative processes and collaborative products, and was finally named the 3+3 Six Traits Digital Collaboration rubric, for future reference referred to as the 3+3 Digital rubric. See Appendix P for the technical, inter-rater and initial utility studies for this final rubric. This appendix also includes descriptive statistics and displays used to compare of inter-rater scoring by group and trait.

Phase 3: Scoring of Student Work Through Within-Case Analysis

This is the specific Phase where student work was scored in order to address RQ 1 and 2, leading to discoveries pertinent to RQ3. Scoring of the data set of 33 Notebooks occurred following the development of the final 3+3 Digital rubric. The rubric was used to score student sample Notebooks and determine a proficiency level per case, or student collaborative group. The scoring yielded information to address Research Questions 1 and 2. The relative rubric responsiveness to student work samples was also evaluated in this scoring stage. Descriptive statistics and displays were prepared in this phase for the work sample**.**

Phase 4: Examination of Trends and Patterns Through Cross-Case Analysis

In this phase the final step of the Notebook interpretation for Research Question 1b and Research Question 2 was to create a typology of patterns of skill development that match construct definitions, if possible, or to better explicate the construct if the data support an alternate view of student use patterns and trends. Using information coded directly from student work sample Notebooks, scored on the rubric, and quantified with a coding checklist, trends in student use of the shared documents Notebook were explored for organized patterns of student use, and any pattern sub-categories that may describe patterns of use in greater detail.

Student Notebooks were reviewed using Body of Work and Cross-case analysis of scores and traits displayed to determine broader group patterns of Notebook use. Diagnostic analysis of individual group Notebooks for a deeper analysis of group patterns of sub-skills and behaviors provided information to be used in a cross-case analysis of these sub-skills and behaviors to discern if behaviors may contribute to the broader group patterns of displayed collaborative skill. As suggested by the literature, notice was taken both of what patterns and behaviors were present as well as what was absent, and patterns discovered are discussed in Chapter IV.

Phase 5: Examination of Skill Areas for Instructional Design

The Body of Work method, Cognitive Task Analysis, and Backward Design principles were used to analyze the assessment findings to categorize skills per domain to develop instructional categories that might aid in planning and resource allocation for instruction in digital collaboration.

Cognitive task analysis. CTA is described by Stanton (2006) as a set of methods to identify the cognitive skills needed to perform a task efficiently, with the break down and study of individual elements of the task. Steps identified in CTA include a) determine task-specific processes; b) identify a strategy for performing the task; c) check the model against a set of representative task instances to assess performance on the task; and d) evaluate the model. Kieras and Meyer (2000) explain identifying task strategy as an intuitive process when a system has yet to be developed, with the predicted assumed strategy tested by the success of performance with use of the model developed for the task strategy. Confounding cognitive task analysis is the human factor; there may be more than one task strategy to facilitate the task production, or people may follow optional task strategies that were not predicted, and display productive or non-productive outcomes.

Hierarchical Task Analysis (HTA) consists of a system of goals and sub-goals, with goal-directed behavior involving the use of sub-goals related to an overall plan or strategy with sub-operations in the hierarchy to achieve the overarching goal or task (Stanton, 2006). The basic method for application of HTA is described by Stanton as: a) define the purpose of the analysis; b) define the boundaries of the system description; c) gather information about the system to be analyzed from a variety of sources; d) describe the system goals and sub-goals; e) link goals to sub-goals and describe conditions where sub-goals are triggered; f) verify analysis with subject matter experts; and g) be prepared to revise the analysis.

HTA can be useful to critically assess aspects of a defined type of work, or to clarify aspects of training or procedures (Militello & Hutton, 1998). HTA helps instructional designers understand the nature of the domain, scope and organization of the work; perform error analysis and prediction; identify performance standards and conditions; and assess the presence of environmental or situational task stresses (Stanton, 2006).

Applied Cognitive Task Analysis (ACTA) is an approach useful for systems and instructional design that involves creating a task diagram, a knowledge audit, and a simulation interview (Militello & Hutton, 1998). The task diagram is a broad overview of the task that identifies difficult cognitive elements, and breaks the task into sub-tasks. The knowledge audit seeks to describe the skills of an expert at the task in order to describe appropriate examples and to bring forward knowledge categories that characterize expertise, and may involve components related to task performance such as situational awareness, prediction, diagnosis, cuing, metacognition including self monitoring, recognizing anomalies, and improvising. The simulation interview with Subject Matter Experts (SME) analyzes performance within a contextualized scenario and addresses items like events, actions, assessment, critical cues, and potential errors to uncover potential novice versus expert comprehension and decision-making differences.

In this study, the task of collaboration in a digital environment was analyzed consistent with CTA, for procedural knowledge and the production rules required for task performance. Concepts from HTA were employed with respect to the subsystems of collaboration and ICT use, as well as the sub-operations implicit to the operational goals in each system. For example, communication of content to team members is necessary to work towards a collaborative team response. This also aided in determining error taxonomy framed as skills deficit. ACTA practices such as the task diagram and knowledge audit helped to clarify levels of performance ranging from novice (Emerging on Digital Collaboration Rubric) to expert (Capable distinction on the rubric). The ACTA model simulation offered a contextualized manner with which to walk through the analysis of the overall constellation of tasks and sub-tasks.

Backward design. Rather than deciding what to teach and giving an assessment at the end of the unit to see what students learned, Backward Design principles start with deciding what students should learn, and how that would be measured or assessed, before going through the process of deciding how and what to teach to help students achieve the stated desired learning outcome. Wiggins and McTighe (2001) describe backwards design as a "purposeful task analysis" that calls for outlining goals for assessment evidence of learning outcomes before planning the instruction towards those outcomes, in order to create more clearly defined teaching and learning targets (p. 8, 2001).

Wiggins and McTighe (2001) frame the design process as a multi-phased process across three stages. The phases include addressing the key design question for each stage; followed by design considerations and design criteria in order to ascertain what the final design accomplishes; with these phases applied to each of the three stages. The first stage seeks to determine what is worth learning and what is required of understanding; the second stage asks what is evidence of that understanding; and the third stage determines what learning experiences and instruction will promote understanding, interest and excellence with respect to the learning goals.

Following this design process should result in a coherent instructional sequence that will promote targeted teaching and learning towards explicit conceptual understanding with the acquisition of essential enabling knowledge and skills, as evidenced by a continuum of valid and reliable assessments. Student needs also shape instructional design, and student ability in prerequisite knowledge and skills must be identified. Childre, Sands, and Tanner Pope (2009) suggest identifying both classroom and individual learner needs as important steps in differentiating instruction and incorporating the accommodations into the backward design process. It is important to analyze multiple sources of data for both student needs and evidence of desired results, to determine appropriate action plans.

The operationalized skills and sub-skills, and the behaviors displayed by students in the Notebooks were examined using CTA, HTA and ACTA and categorized according to general content domain. Expected tasks as defined by the constructs in the assessment were also categorized by general domain. Domains were considered regarding the basic prerequisite enabling skills necessary for being operational in that digital collaboration, consistent with Backwards Design principles (Wiggins & McTighe, 2001). The resulting described domain areas and composite skills are listed in Chapter IV and discussed within the frame of Instructional Design that can support the inclusion of digital collaboration and the many sub-skills in the K-12 curriculum.

It should be noted here again that the digital notebook work product as a single artifact is expected only to begin to explore some of the intellectual demands of such new collaborative tasks online. It was hoped that as teachers are widely being encouraged to include such approaches in their instruction, through technology integration, that the work product samples will help to shed some light on the sub-skills that might be supported with instructional interventions. However it is acknowledged here and discussed in the limitations section that this is only a small part of the necessary research work in this area, although hopefully illuminating across the cases available.

Phase 6: Investigate Potential Professional Development Strategies

Phase 6 explores the leadership aspect of Instructional Design, addressing what practices of professional development might help teachers support the findings in Phase 5. For Phase 6, which again involved only a small exploratory sample, eight educators serving as raters for technical studies in this project (see Appendix P) also were given an exploratory survey about their training in the different sub-skill domains involved in collaborative learning: technology, cooperative learning and social-emotional learning, and their use of these areas in the classroom.

The survey, shown in Appendix N, inquires about the type of professional development experience they received, such as pre-service, in-service, or training educators sought on their own. It also asked for information about use of technology and collaboration in the classroom and district.

In addition, comments made by educators were gathered from discussion and correspondence during the inter-rater moderation sessions (see Appendix P), and categorized by type of support needed.

The survey results and comments from educators were analyzed to discover common experiences and to generate information regarding task-specific educator needs towards implementing digital collaboration in their classrooms. The results of the survey and educator feedback are described in Chapter IV.

Analysis by Phase

The analysis for this study was largely iterative and comprised of many separate analyses, with much of the analysis per phase affecting the direction, development and then analysis of subsequent phases. Analyses are associated with the corresponding numbered Phases of research that are described in detail in the above sections. The analyses are listed by Phase and Research Question with a brief description of the function or purpose in Table 8.

Table 8

Analyses by Phase and Research Question

Research Question	Phase Analysis	Methods	Purpose
RQ1a	I	Body of Work, Discourse Analysis and case-oriented Cross-case analysis	Examine Notebooks to perform qualitative data reduction. Iterative data management activities: code, compare, aggregate, contrast, sort, and order data; Look for patterns, links and relationships.
RQ1a	II	Body of Work	Sort Notebooks by level of assessment task completion, and assess coded checklist qualities against task completion on each work sample.
RQ1a	IIIa	Score with 3+3 Digital rubric; Cross-case analysis	Have a uniform score to use in comparing Notebooks; test use of rubric; Evaluate scoring differences on the first two iterations of the Rubric.
RQ2	IIIb	Descriptive statistics	Determine the existence, strength and direction of the relationships between student age and Notebook patterns

Table 8 (continued)

Research Question	Phase Analysis	Methods	Purpose
RQ1b	IV	Body of Work method and case-oriented Cross-case analysis	Diagnostically examine individual group Notebooks to determine categorical patterns and trends in collaborative skills, sub-skills, and behaviors that may contribute to group patterns of Notebook use.
RQ3	V	Cognitive Task Analysis and Backward Design	Categorize sub-skills for collaboration in a digital environment; Determine the composite skills and domains necessary to plan instruction.
No RQ associated	VI	Survey, qualitative feedback	Needs Assessment for Professional Development

CHAPTER III

RESULTS

As described in Chapter II, the results of this study are related to six phases of research that inter-relate and build upon each other. Results from each Phase will be discussed in turn in this chapter.

Case Characteristics

Table 9 outlines the sample Notebook cases by age group and country. Note that demographic data other than age and country is restricted to country-level use and was not available in this dataset. What immediately becomes apparent in Table 9 is that the 33 cases available in this data set are strongly skewed toward a majority of the case consisting of Age 15 team notebooks from the U.S. Numbers of notebooks available at other ages and from other countries are limited in this sample.

Currently larger field trials are taking place in these countries, with a study design that will provide a more fully representative sample. However for the purposes of this exploratory dissertation of the currently available pilot study notebooks, the sample is more limited, which will be discussed in more detail in upcoming sections. As a descriptive cross-case study of a small number of cases, the sample of 33 cases described here is too small for full representation across the multiple age groups and countries. This is not the goal of the study, however it should be noted here that due to the sample characteristics, more of the information captured in the patterns that are identified through the upcoming phases will represent age 15 student work in the U.S. Exploration of a more fully representative sample will be discussed in Chapter IV, through the implications for future work.

Table 9
Case Characteristics

Demographic	age 11 team products	age 13 team products	age 15 team products
Total number cases (N of cases)	N = 10	N = 5	N= 18
USA	n = 7	n = 4	n = 15
Singapore	n = 2	n = 1	n = 2
Australia	n = 1	n = 0	n = 1

Results of Phase 1: Review and Data Coding of Student Work Samples

Phase 1 of the research involved the review and coding of student work samples to develop a taxonomy reflecting the scope of student work such that the displayed student ability of collaborative skills in the student work samples could be broadly interpreted. See Table 10 for the outline of the data coding process.

Discourse Analysis

In order to determine the level of student ability in collaboration, it was necessary to understand the content that students created, and the possible purpose of their discussion generated, with the ultimate goal of analyzing their content for collaborative elements. Discourse analysis as a process looks at all discourse acts and makes no preconceived judgment about the value. Once discourse acts are coded, then the process is to review coded elements to look for categorical patterns, response or thread development, and develop a picture of the group discursive interaction.

Table 10

Phase 1 Processes and Outcomes

Phase 1: Review and coding of student work samples	Method	Process	Results/Outcome
Phase 1.0 RQ1a	Body of Work method qualitative research	Examine student work samples	Develop familiarity with range of ability and elements displayed
Phase 1.2 RQ1a	Discourse analysis	Code discourse in student work samples for type and purpose	Generate list of traits and qualities represented in student work
RQ1a		Quantify how often traits, qualities or type of discourse appears throughout total work samples	Frequency count for amount of evidence per code or trait to assess commonality of displayed traits
Phase 1.3 RQ1a	Define and categorize coded elements	Analyze traits for creating categories	Develop checklist of traits and qualities displayed

Unit of discourse analysis. The unit of discourse analysis was fragment or utterance, and included any discourse act; even non-verbal acts such as a lone exclamation point or emoticon. A response to an utterance would be coded as a response if just one reply, or a thread, if there were ensuing co-references to a topic. Some utterances were non-verbal, such as emoticons, but are expressive nonetheless. All fragments or utterances were coded, whether they were on or off task. See sample coding on Notebooks 8 and 2 in Appendix N.

Coded checklist of discourse categories. On the basis of the coded student work, an initial task-based Rubric and a coding Checklist were developed to quantify use of categorical discourse and discern general patterns of discourse content or purpose. The initial patterns for category findings from the within-case study were as follows:

Identification. The participant says who they are, and maybe declares an identifying color or font. The assumed purpose is to facilitate discussion via social norms. An example of identification from the Notebook samples is "Dominic is anonymous user 1882."

Role assignment. This is defined as claiming or assigning stated assessment roles such as captain, recorder, scout, decoder. The assumed purpose is to fulfill assessment task directions and facilitate task completion. Examples of role assignment from the Notebooks are "I will be person 1" and "Yu Hao be recorder" or "I want to be decoder."

Task assignment. This is defined as claiming or assigning tasks such as finding clues. The assumed purpose is to fulfill assessment task directions and facilitate task completion. Examples of this from the Notebooks include "We need to decide who will do what task" and "i would like to do the coloring task."

Report content. This is defined as stating what information or answers participants found while working on the task. The assumed purpose is to fulfill assessment task directions and facilitate task completion. Examples of this from Notebooks include the entries "They use red for declining populations" and "Page 8 answer is artic fox."

Seek help. This is defined as asking for assistance. The assumed purpose is to facilitate task completion. Examples for the Notebooks include “Please help me I am stuck on page 9” and “hey, anyone, clue 1 practice?”

Give support. This is defined as providing help or assistance. The assumed purpose is to facilitate task completion. An example of this from the Notebooks is “Click on the toolbar that has the search thingy and type in what you want to find. JingYing.”

Direct process. This is defined as providing unsolicited direction for task orientation to facilitate task completion. An Example from the Notebooks is “hey!!!state name n say something!! We not commounicating at all!!”

Clarify process. This is defined as correcting or redirecting processes for the task. The assumed purpose is to facilitate task completion. An example from the Notebooks is “We have to make sure we don’t end up with the same task.”

Time management. This is defined as awareness of time constraints, and conserving extraneous efforts or planning efforts in regards to time awareness. The purpose is to facilitate task completion. Examples from the Notebooks include “Quick!” and “Can we begin now? It took too much time for us to begin.”

Goal setting. This is defined as deciding on a task or benchmark to achieve and end. The purpose is to facilitate task completion. Examples from the Notebooks are “we ALL HAVE TO DO TWO CARDS!!!!!!” and “role recorder, work on clue one—fly over map—card 2 and 5.”

Develop threads of discourse. A thread is defined as two or more replies to the same initial utterance, such that successive utterance replies co-reference the initial utterance. An example of this from Notebook 11 is shown in Figure 11.

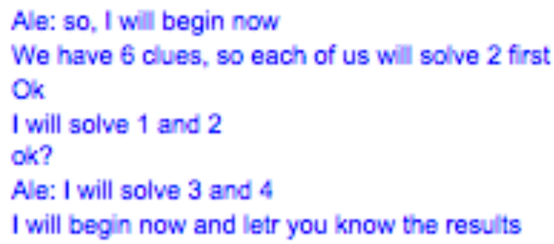

Ale: so, I will begin now
We have 6 clues, so each of us will solve 2 first
Ok
I will solve 1 and 2
ok?
Ale: I will solve 3 and 4
I will begin now and letr you know the results

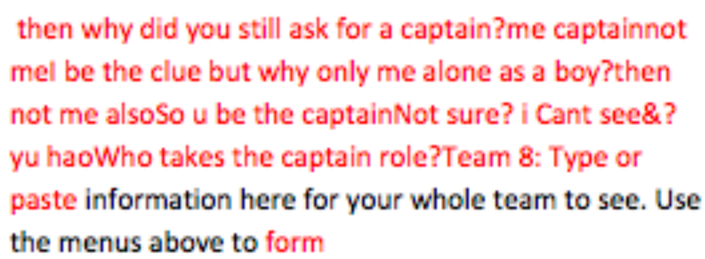
Figure 11. Notebook sample illustrating thread of discourse between students.

Social discourse. This is defined as discursive acts that are social in nature, typically used to connect with others, such as saying "hello", or show respect for others through using culturally appropriate discursive manners, such as prefacing a request with "please" or following compliance with "thank you". The assumed purpose of social discourse is to promote a sense of congeniality or collegiality among group members as a way of developing group cohesion, possibly towards task completion. Examples of social discourse from the Notebooks include "hi"; "thank you sir"; "lol"; "Sup"; "pls reply"; "@_@", and other social text speak.

Text speak and emoticons. This is defined as text shorthand and character use as discursive acts. The assumed purpose is to establish and maintain a social-emotional connection through text-speak or emoticons, perhaps to establish social comfort in lieu of face-to-face contact. Non-sample high school students assisted in evaluating these symbols regarding current use meanings, and the high school student coding was fact-checked on text speak sites such as NetLingo (www.netlingo.com/acronyms.php), Talktalk (www.**talktalk**.co.uk/community/**textspeak**) and other sites.

The most common socially related text speak content displayed in the student work samples were facial representations, such as the wide-eyed, shocked, freaked-out, and questioning faces. The next most commonly symbolized expression was the smile, in various formats, such as squinty-eyed, and big grin. These symbols were perhaps used to establish a friendly connection so as not to appear too business-like in a remote-located collaborative situation where the social mood or connection and transmittal of emotions cannot be established by body language.

Role conflict or confusion. This is defined as discursive acts relating to confusion or disagreement over who will take what role. The assumed purpose is to clarify or change roles assignment or the process of role assignment. Two examples of this from the Notebooks are illustrated in Figure 12.


then why did you still ask for a captain?me captainnot
meI be the clue but why only me alone as a boy?then
not me alsoSo u be the captainNot sure? i Cant see&?
yu haoWho takes the captain role?Team 8: Type or
paste information here for your whole team to see. Use
the menus above to form

Example two:

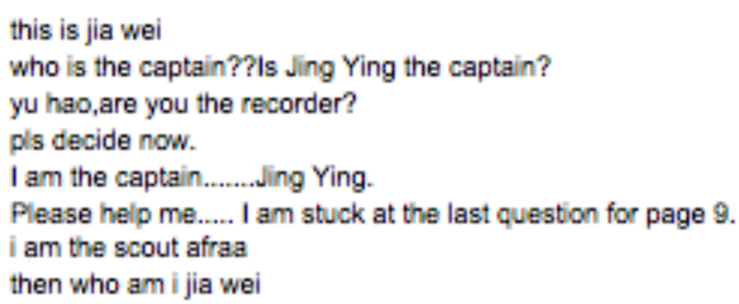

this is jia wei
who is the captain??Is Jing Ying the captain?
yu hao,are you the recorder?
pls decide now.
I am the captain.......Jing Ying.
Please help me..... I am stuck at the last question for page 9.
i am the scout afraa
then who am i jia wei

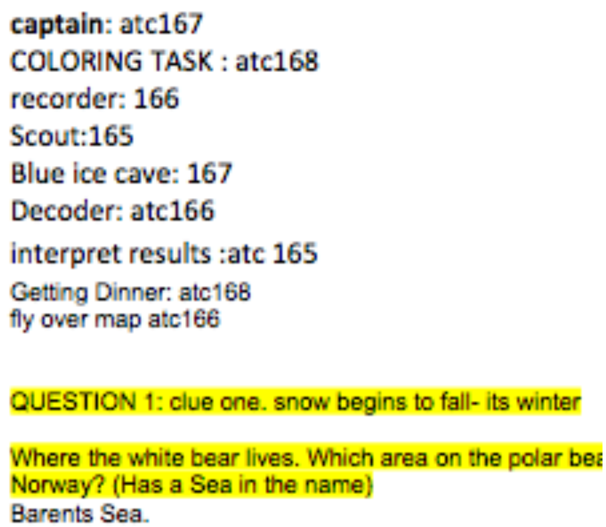
Figure 12. Two Notebook samples display student role conflict or confusion.

Task conflict or confusion. This is defined as discursive acts relating to confusion or disagreement over who will work on what task. The assumed purpose is to clarify or change task assignment or the process of task assignment. Examples of this from the Notebooks are “Hillary: I cant answer 5 and 6 until you have solved 3 + 4 Ale, what should I do in the meantime?” and “Can I pick what I want to do?”

Affective statements. This is defined as discursive acts that only relate emotion. The assumed purpose is to express emotion or possibly to connect with the group socially or seek emotional support. While emotion may be implied within discursive acts that contain other categorical content, they are not coded as affective statements. An example of this would be “how do you set this up? don’t get it!!!” as the “don’t get it!!!” with three exclamation points could imply frustration, which is affective. However, as it is not overtly affective, it was coded as Seeking Help. In another example “WHOS ERASING IT??????????????????????????” implies anger, but again, as it was not overtly affective it was coded as task direction. Examples of Affective Statement are as follows: “IM confused” or “this is damn difficult” “this is making me …crazy!!” Confusion was the most commonly expressed affect.

Off-task behaviors or topics. Off-task behaviors or topics are defined as any discursive act that is not related to the process or product of the task, and has not been coded differently. For example, this category does not include social discourse, which can facilitate task through group cohesion, nor does it include affective statements, or role and task conflict or confusion. Off-task topics or behavior may have the possible purpose of sabotaging task completion, but likely just reflect student boredom with or frustration by the assessment task, or some other issues not related to either the group or the task, including issues that are totally unrelated to the school environment. Examples of off-task discursive acts from the Notebooks include “;llo0ouio90” and “wghdfdetbjghftdrtfgdchkahfauygivsawwer” or “i very cold.”

Visual organization. This is defined as any attempt at visual adjustment to the Notebook pages, such as the use of color or font for participant identification, outline formats, threads of discourse separated by space as "chunks," numbers, underlining or other visual formats. These are embedded in discursive acts and not typically overtly discursive on their own. The assumed purpose is to provide an organization to the digital environment facilitates collaboration, with an overarching purpose of task completion. This example reflects one of the few overtly discursive acts of visual organization, although her act is also tied to Identification: "I'm Jenny :) this colour." The example in Figure 13 is from Notebook 32:


captain: atc167
COLORING TASK : atc168
recorder: 166
Scout:165
Blue ice cave: 167
Decoder: atc166
interpret results :atc 165
Getting Dinner: atc168
fly over map atc166

QUESTION 1: clue one. snow begins to fall- its winter

Where the white bear lives. Which area on the polar bea
Norway? (Has a Sea in the name)
Barents Sea.

Figure 13. Notebook sample displaying visual organization.

Total entries. This is a count of the total number of discursive acts in a given Notebook. They were counted to assess whether the number of entries had any relationship with task completion.

Total questions. This is a count of the total number of discursive acts that could be coded as questions in a given Notebook. They were counted to assess whether the number of questions had any relationship to task completion.

Separation of checklist and rubric traits. Categorical codes that were considered specified by the assessment were put on an initial Rubric, see Phase Two below, and the remaining content categories coded through discourse analysis were placed on a Checklist to be used for further qualitative analysis of student work after assessing for task ability. The final Six Traits Checklist of coded behaviors that were not assessment-based Traits is located in Appendix E.

Results of Phase 2: Rubric Development

Phase 2 reviewed student work samples to define commonalities as coded traits and qualities leading to the development of an initial rubric. See Table 11 for explication of this iterative process for initial development of the rubric.

Table 11

Phase 2 Processes and Outcomes

Phase 2: Initial Rubric development	Method	Process	Results/Outcome
Phase 2.0 RQ1a	Rubric Development	Separate coded Checklist traits designated explicitly as assessment tasks in Arctic Trek instructions (ex: “choose a role”)	Develop trait category from constellation of displayed activity that supported or facilitated performing assessment tasks

Table 11 (continued)

Phase 2: Initial Rubric development	Method	Process	Results/Outcome
Phase 2.1 RQ1a	Expert Review	Myself and another educator used Rubric v.1 with two student work samples	Trait “Sharing or Checking Progress” does not adequately capture student discourse to support tasks. Replace with Interactive Regulated Learning.
Phase 2.2 RQ1a	Body of Work method	Sort student work sample Notebooks by level of assessment task completion	Find range of evidence of assessment task completion
Phase 2.2 RQ1a		Assess checklist qualities against task completion on each student work sample	Some qualities do not appear related to task completion, so these are left on checklist and not added into Rubric (ex: # of entries in Notebook)
Phase 2.3 RQ1a	Rubric Development	Use above to choose six traits that represent components of assessment task and four skill levels of displayed evidence	Six Trait Computer-Supported Collaborative Learning (CSCL) Rubric developed for use

Traits

Results from the discourse analysis were used as grounding traits for the Rubric. In the task itself, students needed to choose roles; assign responsibilities; seek and offer help; investigate various clues; and report answers to their teammates to co-construct knowledge and create a shared team answer.

These specific tasks were stated as Traits 1, 2, 3, 4, 5 and 6; the six traits and their defining characteristics are listed below.

- Trait 1: Identification & Role Assignment: Participants identify themselves and take roles.
- Trait 2: Task Assignment: Who is responsible for what tasks?
- Trait 3: Interactive Regulated Learning: Evidence of seeking or offering help; reporting progress; clarifying process; self or group evaluation; time management; task orientation; goal setting; mediation; or appreciation.
- Trait 4: Sharing Content and Resources: Resources, answers or responses to tasks are posted.
- Trait 5: Collaboration: Participants add to, evaluate or offer an alternative response to the shared content.
- Trait 6: Co-Construction of Knowledge: Participants use shared and evaluated content to construct final answers or responses or complete a task.

Expert review. An educator from the field and I independently rated two Notebooks to see how the Rubric would capture the discursive elements displayed in work samples. The initial six-trait rubric had a problematic trait identified in this review. The Trait "Sharing or Checking Progress" did not adequately capture student discourse to support tasks. It was coded as a Trait due to its centrality in many work samples, yet many higher scoring groups did not engage in overt or visible progress reports or checks, and their lack of demonstrating this trait led to a lower overall score, although they completed a high quality product. Initial review from the field reflected my discomfort with how this trait fit the construct of collaboration. Educators in field review agreed trait Reporting Progress was problematic in that it did not reflect nor capture the range of discourse regarding group work behaviors.

There were a variety of coded categories on student work that did not fall under "Sharing or Checking Progress" such as Seeking Help, Providing Support, Directing or Clarifying Process, or Task Orientation, Goal setting, Time Management, or Mediating Conflict. I decided that these behaviors did facilitate task accomplishment, and should be able to be reflected on the rubric, even if there was variation in how often or in what combinations they occurred. This led to the development of the Trait 3 Interactive Regulated Learning. Interactive Regulated Learning is a more comprehensive trait and is better able to capture group-oriented metacognitive behaviors than the previous trait narrowly defined around explicit reporting or checking on progress.

Interactive regulated learning. Interactive Regulated Learning is self-regulated learning with a group focus, such that the processes are evidenced individually and/or mediated collectively through group communication, participation, or facilitation of those processes within the group. This revision of Trait 3 was developed based on the coding and content categorizing from the discourse analysis in Phase 1. A large number of discourse fragments and threads identified were devoted to seemingly isolated traits, yet most fell into the category of self-regulated learning.

Self-regulated learning. Self-regulated learning is a social cognitive construct defined as a constellation of metacognitive, behavioral and motivational strategies or processes that allow or support a learner to mediate his or her learning (Zimmerman, 2000). Specific behaviors involved include goal setting, self-monitoring, self-evaluation, task orientation, time management, and help seeking. Goal setting can be defined as setting specific outcomes including both performance and process outcomes (Zimmerman, 2000). Self-monitoring is defined as directing one's attention to one's own learning processes with an eye towards directing efforts to task and evaluating progress in the effort (Dabbagh & Kinsantas, 2005). Task orientation is attention to task, with the use of strategies, tools and processes, including organization and planning, that the learner believes will enable task accomplishment. Time management supports the other self-regulatory processes and help seeking is a self-regulatory process whereby the learner has used self-evaluation skills to identify when he or she needs assistance to complete a task.

Group-meditation of self-regulated learning skills. As this assessment task took place in a collaborative group environment, the self-regulatory processes were often directed at others. Examples of this include: "Hurry, find your answers we are running out of time" and "stop doen that dang lets do our work! okay number five." Other examples were in support of others "uhhhh 4 is supposed to be u just assign it to any one ok?" and "ya wat do you need help on?" Still other examples facilitated the process of others such as "How many colors do you see team?" I decided to call Trait 3 Interactive Regulated Learning because the group was engaged in self-regulated learning processes together; individual processes were connected to those of the other group members.

There is only circumstantial evidence that one group member's overt explicit demonstration of self-regulated learning could promote that in another group member, but nevertheless as the discourse was often reciprocal, I thought this Trait reflected group mediation.

Preliminary Work Sample Assessment and Range Finding

Using the initial revised Rubric and the Checklist, student work sample Notebooks were scored and sorted by level of assessment task completion. The goal was to find a range of evidence of assessment task completion to help describe the scoring categories. The categories that emerged were Non-collaborative, Emerging, Developing, and Capable. The majority of student work samples reflected the Non-collaborative category due to non-use of the Notebook. Of groups who did access and choose to use the Notebooks, most were in the Developing to Emergent categories.

Preliminary Work Sample Assessment for Significant Traits

As the main purpose of the Rubric is to assess student ability to perform a collaborative group task, specifically the Arctic Trek task, I wanted traits appearing on the Rubric to be significant, meaning tied to task completion. In order to assess the initial revised Rubric for relevancy to task, I assessed checklist qualities, that is elements coded from student work that were not initially assigned to the Rubric, against task completion on each student work sample. Some qualities did not appear related to task completion, for example the number of entries or questions in a Notebook, so these were left on Checklist and not added into Rubric.

Six Traits Digital Collaboration Rubric

The initial Rubric, the Six Traits Digital Collaboration Rubric, had a format similar to well-established curricular rubrics that are familiar to teachers in most content areas. Traits are described with a guiding question and four levels of proficiency evidenced by student work examples. The Six Traits Digital Collaboration Rubric is shown in Appendix D. This rubric was used to initially score the student work samples, and subsequently underwent further revision after examining the level at which the Rubric captured of student ability.

Initial Assessment of Student Work, Using the Six Traits Rubric

Using the first iteration of the rubric, the Six-Traits Digital Collaboration Rubric, the mean score was 5.4 and the median score was 4, from a total possible of 18 across the 0-3 score levels of the six traits. Eleven groups out of the thirty-three total scored at 50% or better on the rubric, and five scored at 67% or better. Seven groups did not use the document at all and scored a zero, and four additional groups used the Notebook very sparsely leading to a score of one; these groups accounted for one-third of the sample. See scores from evaluation with the first iteration of the Rubric, the Six Traits Digital Collaboration Rubric, in Table 12.

Table 12

Overall Notebook Scores for Six Traits Digital Collaboration Rubric

Sample	Mean	Median	Mode
N = 33	5.4	4	0

Note. The Total overall score possible = 18.

Evaluation of Six Traits Digital Collaboration Rubric Use for Student Work Assessment

Upon analyzing student work samples against scores generated from the Six Traits Digital Collaboration Rubric, it was noted that similar overall scores on the Rubric did not always relate to similar quality of collaborative work. For example, using the Six Traits CSCL Rubric, Notebooks could score 12/18 overall, which is a high score for this sample group, but not exhibit much beyond Emerging for actually being able to create a collaborative product or complete the assigned assessment task. The rubric therefore as composed did not have sufficient sensitivity to capture student skill ability within this scoring frame.

Expert review of Six Traits Digital Collaboration Rubric. An educator from the field used the Six Traits Digital Collaboration Rubric to score two work samples and independently offered feedback that matched my observation above, that the overall score on the Rubric didn't readily tell her, as a teacher, how student skills were distributed with regards to the structure or function of collaborative work; whether they had basic collaborative skills that needed harnessing, or whether they could create a product without substantial evidence of working together on the product. This review confirmed my observations and led to a redesign of the rubric, as described below.

Rubric revision: 3+3 Six Traits Digital Collaboration Rubric. Based on the concerns above, the original one-dimensional six-trait rubric was split into two dimensions to give more specific information on student performance, each with a component score; see the 3+3 Six Traits Digital Collaboration Rubric in Appendix E.

The 3+3 Six Traits Digital Collaboration Rubric measures:

- Collaborative Learning Processes with Traits 1, 2 and 3
- Collaborative Learning Products with Traits 4, 5, and 6

Each trait carries a possibility of 3 points, for total sub-component scores of 9 and a combined potential Digital Collaboration score of eighteen.

Becoming a two-dimensional rubric allowed scores to reflect relative strengths and weaknesses across the dimensions, rather than being averaged together. Aside from becoming a two-dimensional rubric, there were only minor adjustments made in the language of the trait descriptions; see Appendix D and E for versions two and three of the rubric.

The rubric was also adjusted to reduce confusing language. Specifically, in Trait 4, associated with Collaborative Learning Products, "Shared Content" was rewritten to be "Sharing Content and Resources" in order to clarify that providing resources for group members to consider may be just as or more useful than simply posting a content-based "answer" to a task related question.

Results of Phase 3: Assess Student Work and Evaluate Rubric

In this highly iterative phase Student work samples were scored using three iterations of the developed rubric each with a total of 18 points possible. First, the initial Six Traits Digital Collaboration Rubric was used to assess student work samples, and then the scored work samples were used reflectively to evaluate the rubric. Such evaluation, along with reflection and expert review, led to the revision of the Rubric to a two dimensional model, the 3+3 Six Trait Digital Collaboration Rubric, to better capture student ability in multiple aspects of collaboration. The 3+3 Six Trait Digital

Collaboration Rubric was then employed to assess the student work sample Notebooks again, performing better than the initial Six Traits Digital Collaboration Rubric in capturing student abilities. The group scores from this rubric were analyzed descriptively and the Rubric was used by other raters to assess Notebook samples to evaluate the Rubric for reliability; see Table 13 for an overview.

Table 13

Phase 3 Processes and Outcomes

Assessment of student work and evaluation of Rubric	Method	Process	Results/Outcome
Phase 3.0 RQ1a	Assessment of student work using Rubric	Use Rubric version 1 to score student work samples	Quantified range of skill displayed in Notebook use
	Evaluation of Rubric use for student work	Analyzed Notebook scores against overall task completion and other sample Notebooks	Discovered rubric score on process traits generated overall lower score even when group created a product
Phase 3.1	Expert review	Educator feedback regarding Rubric version 1 against three sample Notebooks	Educator in field gave feedback reflecting above observation
Phase 3.2	Rubric revision	Restructure Rubric to two dimensions: process and product	Developed 3+3 Six Trait Digital Collaboration Rubric
Phase 3.3 RQ1a	Assessment of student work	Used 3+3 Rubric to score student sample Notebooks	Scores on version 2 of Rubric better reflected evidence of student ability

Table 13 (continued)

Assessment of student work and evaluation of Rubric	Method	Process	Results/Outcome
Phase 3.4	Assessment of student work descriptive statistics	Comparison of inter-rater scoring by group and trait	Scoring trends of sample Notebooks similar between groups of inter-raters, showing rubric coherence
Phase 3.4 RQ1b RQ2	Assessment of student work Descriptive statistics	Examine Notebook rubric scores by age	Slight age trend between 11 and 15 years olds with respect to mean score on rubric
Phase 3.5	Inter-rater reliability	Educators from the field use Rubric to score 8 sample Notebooks in asynchronous format	Report Traits 1 and 2 difficult to score due to lack of context for educators and confusion about assessment tasks
		Moderated session for Educator use of Rubric to score 8 sample Notebooks	Similar feedback regarding Trait 1; similar confusion regarding assessment context

Secondary Assessment of Student Work Using the 3+3 Rubric

Next, a second assessment of student work was completed using the new 3+3 Rubric to score student sample Notebooks. Scores on version 2 of the rubric better reflected evidence of student ability. Whereas the overall scores remained basically unchanged, see Tables 14 and 15, the two-dimensional rubric captured differences in the types of ability displayed in student Notebook work samples. Scoring work samples with the second iteration of the rubric, the mean score on the Process dimension was 2.97 and the median was 3. The mean score on the Products dimension was 2.73 and the median was 2.5.

The scoring indicates that using collaborative processes was somewhat easier for students than creating a collaborative product, see Table 14. This confirms some of the thinking in the ATC21S framework, outside the scope of this dissertation, that suggests the Producer construct is shifted higher in difficulty for digital collaborative learning as compared to the Consumer construct.

Table 14

Overall Scores for Process and Product Dimensions on 3+3 Six Traits Digital Collaboration Rubric

Dimension	Mean	Median	Mode
Collaborative Processes	2.97	3	0
Collaborative Products	2.73	2.5	0

Note. Total score per dimension = 9

Assessment of Student Work Descriptive Statistics

All of the student work sample Notebooks were rated for a final time, using the 3+3 Six Traits Digital Collaboration Rubric. Table 15 displays the total composite scores of combined Product and Process dimensions for all 33 cases.

Table 15

3+3 Six Traits Digital Collaboration Rubric Combined Total Scores by Group

Score	Frequency	Cumulative Frequency
0	7	7
1	4	11
2	1	12
3	2	14
4	2	16
5	2	18
6	0	18
7	2	20
8	2	22
9	2	24
10	2	26
11	2	28
12	1	29
13	0	29
14	4	33
15	0	
16	0	
17	0	
16	0	
Totals	33	

Note. Total Score = 18   N = 33

The Product, Processes and Combined stem and leaf plots featured in Figure 14 show a break down of the scores per the two dimensions and the composite scores.

Collaborative Learning Processes Stem and Leaf Plot

Stem	Scores out of nine possible points
0	0 0 0 0 0 0 0 0 0 1 1 1 2 2 2 3 3 3 3 4 4 4 4 4 5 5 5 5 6 7 7 8 9

Collaborative Learning Products Stem and Leaf Plot

Stem	Scores out of nine possible points
0	0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 2 2 3 3 3 3 4 5 5 5 5 6 6 7 7 7 7 8

Combined Collaborative Composite Stem and Leaf Plot

Stem	Scores out of 18 possible points
0	0 0 0 0 0 0 0 1 1 1 1 2 3 3 4 4 5 5 7 7 8 8 9 9
1	0 0 1 1 2 4 4 4 4

Figure 14. Collaborative learning stem and leaf plots. These displays show scores from the two dimensions and the composite scores.

Scores by Trait

The strongest traits displayed based on the overall scoring were identification or role assignment, interactive regulated learning (asking for and offering help, reporting progress, clarifying processes, time management, task orientation, goal setting, self or group evaluation) and sharing content. These are tasks that some students have experience with or exposure to, although sharing content with other students is not a norm in some classroom situations unless sharing publically when answering a question in class. However, even in these simpler tasks, many cases did not display much mastery of traits, such as collaboration or even task assignment.

The least typically seen of the six traits rated on the rubric was co-construction of knowledge. This arguably requires mastery of some of the other traits. Also the task may not have elicited this behavior sufficiently from students without pre-instruction on how to co-construct digitally. Therefore it is not surprising that this trait was seen less often. However, since this is a skill that teachers would like to see happening in the classroom when undertaking digital collaboration, this finding points to need for possible instructional supports, to be addressed in a later research question.

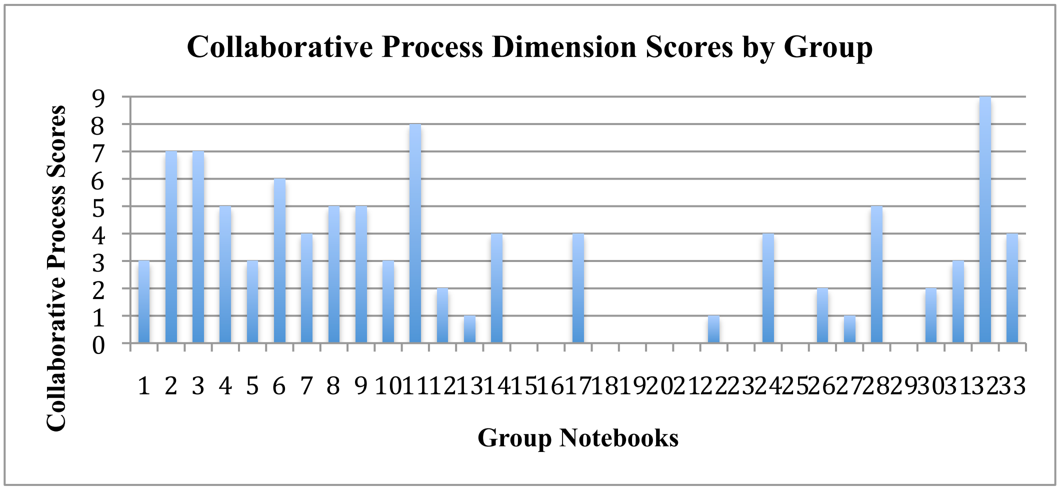
Scores by Group

The scores by case (team or group) were varied, with high, low and mid-range cases. The two dimensional scoring rubric reflected the relative difficulty of scoring higher on the Product traits as compared to the Process traits. The two charts in Figure 15 also demonstrate that a group could score high in one area but not the other, such as Group 5, Group 11 and Group 28.

Scores by Age

The mean and median per age are presented in Table 16. As noted previously, the numbers of students by age in the sample were uneven, and small for some age groups, with 10 cases for 11-year-olds, 5 cases for 13-year olds, 18 cases for 15 year-olds. Descriptively, the age 15 students have a slightly higher mean overall and have fewer notebooks scoring zero. Additionally, as can be seen in the samples in the appendices, 11 year olds showed less social discourse, and were the only group to display role conflict.

However overall, there was not as dramatic a difference by age as might be expected based on the literature review in Chapter I. This will be discussed more in Chapter IV.



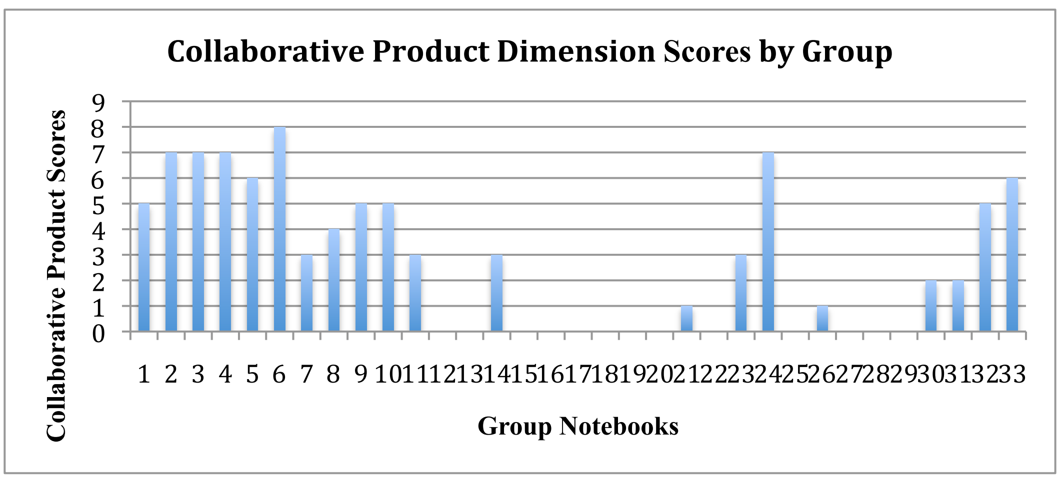


Figure 15. Collaborative Process and Product Scores by Group.

Inter-Rater Reliability

A major component of the study is the development of the rubric as an assessment tool for computer supported collaborative learning in a 21st century skills curriculum. As such, it is important that the rubric be reliable by performing with some degree of consistency across raters. Eight student Notebook samples were purposively chosen to be representative of differing student ability as reflected by the scoring of the researcher from low, medium and high scoring groups. Professional educators currently practicing

Table 16
Notebook Scores By Age Group

Age	Sample (N)	Mean	Median	Mode
All Sample ages	N = 33	5.7	4.5	0
11 year olds	n = 10	5.7	5.5	0
13 year olds	n = 5	3.8	0	0
15 year olds	n = 18	6.2	5	1, 14

Note. Total score = 18

in the field analyzed these eight student samples. The raters provided scores for the eight groups as well as qualitative feedback on the instrument, the process of inter-rating, and the assessment process that generated the student work. Of the total eight inter-raters, three were asynchronous and five were part of a moderated group.

Inter-Rater comparison by group. Group scores were compared between the different raters. Groups with lower overall scores showed the most consistent ratings, likely due to the low-level of complexity in determining skill when little skill is evidenced. Groups with higher scores varied as to the cohesiveness of the ratings. One factor may be the qualitative issues involved such as not recognizing traits due to misspelling, non-standard English, text speak, lack of clarity about the structure of entries and so on. Raters reported confusion about role assignments versus task assignment and stated that they often had difficulty distinguishing between those traits. An inter-rater sample is shown in Figure 16. It shows a series of four raters (1 rater for each series) each independently rating a single case (Case 33) across the six traits shown on the horizontal axis, and at the levels of performance shown on the vertical axis. For this case, no rater differed by more than one level on any trait rating; many of the trait ratings were at the same level. This was true of most cases. In only a few situations did a case generate a trait score differing by more than one level, and even then the outlying rater was a single rater among the full set of raters, who clumped more closely within one level in their ratings.

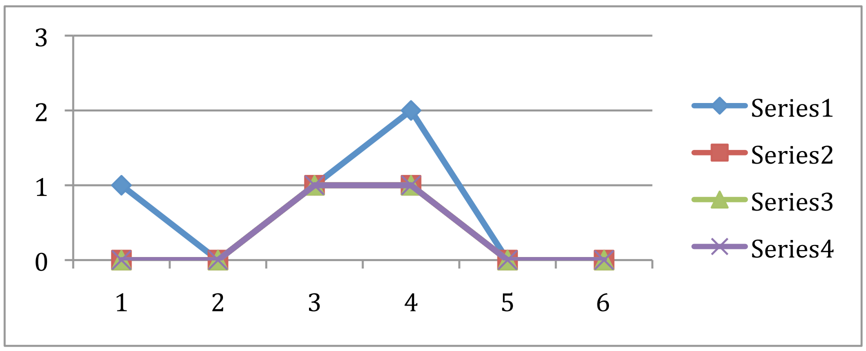
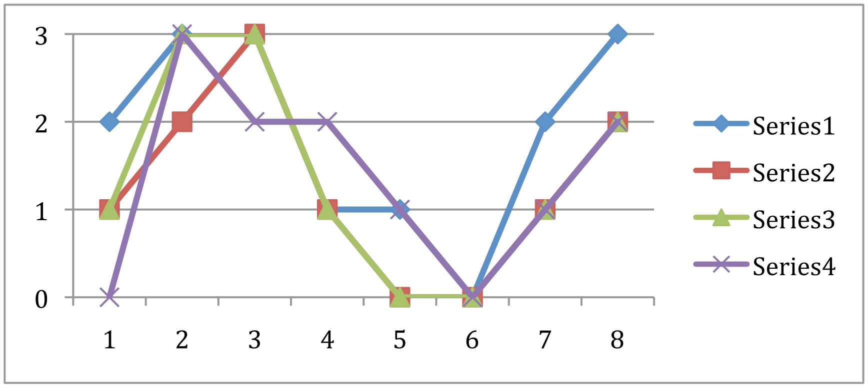


Figure 16. Asynchronous Inter-Rater Comparisons for Case 33. A series of four raters (1 rater for each series) each independently rating a single case (Case 33) across the six traits shown on the horizontal axis, and at the levels of performance shown on the vertical axis.

Descriptively comparing raters across cases and traits, Figure 17 displays the work of four raters evaluating eight cases on two different traits, Trait 4 of Shared Content and Trait 6 of Co-construction of Knowledge. It exemplifies how results for a trait level analysis show that there is some variability between raters on exact point value assignment to student work samples, but that overall raters share a fair degree of consistency. The upper graph in Figure 17, Trait 4 is an example of the occasional outlier, with raters within one score level of each other across the 8 cases shown with the exception of Case 1, where three raters agree within one score level but one rater differs.

Trait 4: Shared Content



Trait 6: Co-Construction of Knowledge

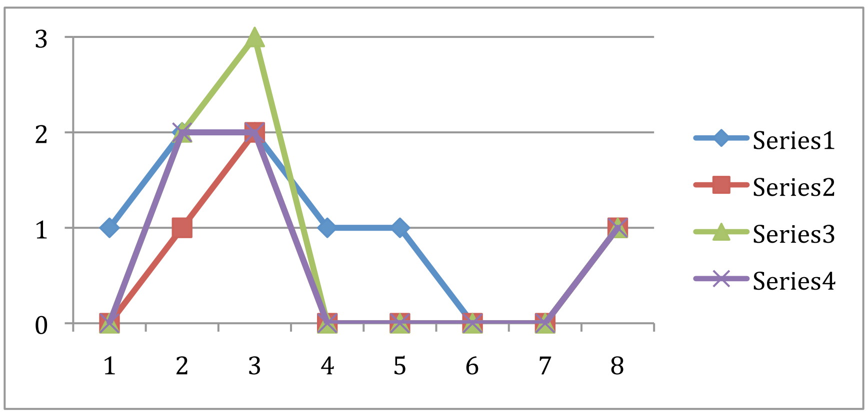


Figure 17. (top and bottom). Inter-Rater Comparison of Traits 4 and 6.

Overall, Trait 1, identification and role assignment, widely showed the strongest agreement among raters. Trait 2, task assignment, had somewhat more of the one-level variation, probably due to confusion about a distinction between role assignment and task assignment subsequently mentioned by raters and noted in future refinements for the rubric. Trait 3, interactive regulated learning is the only trait where the value direction of the raters is not entirely consistent, meaning scores between raters do not move up and down together, although in six of the eight groups at least two or three raters agree with each other. This trait describes group mediated metacognitive skills, many of which could be expressed or evidenced with just one or two words. Trait 4, shared content, is a straightforward descriptor, but there is still variance with the researcher more sensitive and the possibility that non-standard communication by students makes it difficult for raters to see the evidence of this trait. Trait 5, collaboration, and Trait 6, co-construction of knowledge, were both dependent on group success with Trait 4, shared content, and reflect increased depth in content sharing. The further distinction for Trait 6 includes using collaborative comments to jointly revise and agree upon the response or new ideas regarding content.

Following the use of the rubric by asynchronous inter-raters, a face-to-face, moderated group of educators practice rated using Notebooks 32 and 33. These raters individually rated the same eight samples the other inter-raters used. The results of the moderated ratings displayed somewhat improved agreement among raters, with fewer one-level differences, and more consensus in the rater comments that the rubric criteria were understood.

Qualitative Review From Educator Raters

Educators serving as inter-raters offered feedback on the student work or student assessment process, the inter-rater process, and the rubric itself. Regarding student assessment factors, while raters were given rubric administration instructions that included an overview of the student assessment, there was still a lack of understanding regarding how much content there was in the assessment so they could rate how well students addressed it. Another concern was whether roles such as decoder included tasks, and why the students didn't have a better grasp of what they were being assessed on. Educators voiced confusion about the assessment task and how explicitly the students had been instructed or guided to identify themselves and take a role, as well as either take a task or assign a task to another. There was confusion over a role not automatically being connected to a task as is often typical in the field.

One educator pointed out that the directions given the students were three step directions and that "working with people" was sandwiched between the more familiar concepts to students of "use tools" and "find answers." The educator further pointed out that the students may not have fully understood they were being assessed on their collaboration skills through the documentation of collaborative activity.

Possible effects of student ability in non-assessed content areas was also discussed. There was mention that students may have difficulty with written expression, and being assessed through written documentation of both applied and abstract skills and content makes it difficult to tell what interaction or interference those elements may have with collaboration. While for the full task set, there were many opportunities for expression in other formats, for this particular work artifact, the mode of communication was written text shared between students.

Possible effects of teacher/rater ability in assessed domains was also discussed by the educator raters. There was acknowledgement that many teachers have never engaged in computer-supported collaborative activities themselves, and may also experience very little face-to-face collaboration, and this could interfere with both teacher abilities to support these skills in students, and to perform ratings and judgments of student work. Educators did consider the juxtaposition between finding the correct answers and working collaboratively, and considered subtle facets of a collaborative environment. One educator commented, "*All answers were completed, but they were not acknowledged* *by each other. They completed the task well but seemed to work independently; therefore, I had a difficult time deciding whether to give a 0 or a 3 for "Trait 6 Co-construction". Can absence of a correction be considered agreement?"* A wider range of task as exhibited by scoring not a single artifact but more portions of tasks and more tasks would give a more complete view of such considerations.

Amid discussion about the distinctions between Trait 5 collaboration and Trait 6 co-construction of knowledge, there was a debate on whether the assessment single work sample alone provided sufficient opportunity for displaying Trait 6. There was a feeling among the rater group that because students were instructed to find clues to determine pre-defined answers, the task did not support enough knowledge creation to show the reaches of collaboration. While it was true that even on the simpler task few students showed much mastery of digital collaboration, as one rater remarked, "Creation of knowledge requires a deep task, with possibilities for synthesis, and such." One perception was that students did not have opportunities to co-construct knowledge or bring in new thought or meaning, therefore the rubric was not able to capture the student work sample potential to its fullest extent. Another consideration was whether at 45 minutes for the entire task there was enough time to draw out the full co-construction of knowledge possible.

The asynchronous educator-raters expressed that they would have preferred a moderated training as is held typically for rubric introduction, such that each member of the team rates a couple of samples using the rubric, with a discussion to review the scores given and the rationale, and come to agreement on what the appropriate point assignment would be per trait. Then raters typically discuss each trait with respect to student samples

Unfortunately, due to time and location issues, no such training was available for the asynchronous raters. As one educator pointed out, using rubrics to rate student samples for assessment is typically a collaborative process itself. This was addressed in the collaborative moderation conducted subsequently.

Raters who had a moderated session said that the process was familiar to them, as many had used the Six Traits Writing Rubric. They were surprised that negotiating for consensus about what student evidence from work samples fit which trait level was a goal of the moderation. As one teacher remarked, "When using the Writing Rubric it is acceptable to have 1 degree of difference—not consensus." Teachers did dissect the descriptions under each level of each trait, and with the exception of being bothered by Trait 1, and temporarily confused by Trait 6, the process was basically agreed to be understood by the participants.

Rubric utility. One purpose of this study was to contribute to the guidance of instructional design and professional development for collaborative learning and problem solving in K-12 education, as expressed in Research Question 3. The educators thought that the rubric was useful for a teaching grid in presenting and assessing collaboration in a digital environment. All raters approached this rubric favorably, noting that they had not seen any document prior to this rubric that could guide instruction in digital collaboration or that described skills regarding the use of Google docs, CSCL, or even collaboration in non-digital environments.

One educator noted that the high schools in her district are slated to begin teaching digital collaboration using Google docs during the 2012-2013 school year, but no one has of yet provided any instructional guidance. She commented, *"I think this* *rubric is the first step in developing interactive group projects."* The rubric could be generalized to other assignments, such as the Tumalo Community School assignment for the 4th grade class to decide, in collaborative groups, on behavior guidelines and strategies using Google docs as a medium. Implications of this will be further discussed in Chapter IV.

Qualitative Review from Researchers in the Field

The rubric was reviewed by Dr. Gerry Stahl, Associate Professor in the College of Information Science and Technology at Drexel University, and a widely published scholar in the field of CSCL. Stahl stated that the rubric, operating within the educational paradigm of classroom instruction, is "likely to be better comprehended by teachers than anything he might propose" (Stahl, April 8, 2012, personal communication). He described that although he had no prior experience with a classroom rubric such as this, he stated that the rubric did capture many of the elements of collaboration. He was unsure how much it could capture group cognition, defined as the emergence of ideas through group discourse such that ideas are built on to produce new knowledge that is co-constructed by the group process; going beyond the original ideas or beliefs of any individuals. He was also uncertain that the concept of co-construction was adequately conveyed to teachers and acknowledged that the language used in the rubric, such as "sharing content" could be open to various interpretations not consistent with co-construction of knowledge.

The review from the research perspective illuminates the gap between researchers and practitioners in the field, whereby constructs are explored deeply in great detail, yet the results often are not communicated to practitioners at the K-12 level and then rarely in a format useful to practice. Conversely, the direct needs of educators in K-12 practice may not often be the focus of research in the field. More on this will be discussed in Chapter IV.

Results of Phase 4: Examine Categorical Patterns and Trends in Student Work

A main objective of this project was to examine patterns and trends in student ability in collaborative work in a digital environment, as outlined in RQ1b. An examination of displayed student ability in the sample Notebooks by age as evaluated by the 3+3 Six Traits Digital Collaboration Rubric, and discussed in section above on page 111, showed some but not substantial differences across the age groups of 11, 13 and 15 year olds. However, there are clear patterns and trends related to Notebook use in this sample, regardless of age groups. The student work, scored using the 3+3 Six Traits Digital Collaboration Rubric, reflected a general lack of skill in using collaborative documents in a digital environment, with most groups placed in the Emerging skill category. Analysis of the student work discussed in this section looks at the skills displayed on a diagnostic level. Table 17 outlines the processes used to diagnostically examine the sample Notebooks for patterns and trends.

The discourse displayed in student Notebook work samples was in general sparse, with only nine groups having more than 20 entries in their Notebook—and an entry counted down to utterance or emoticon level. The average number of entries for the nine more heavily used Notebooks was 49.5. Six out of thirty-three groups did not access their collaborative Notebook at all. Two or three groups appeared to have erased all signs of their collaborative work, and left just the neatly numbered clues with answers and a list of group member identification numbers.

Table 17

Phase 4 Processes and Outcomes

Phase 4: Examination of patterns and trends in student work	Method	Process	Results/Outcome
Phase 4.0 RQ1b	Body of Work	Review student Notebook use for scores and traits displayed	Determine broader group patterns of Notebook use
RQ1b	Body of Work	Diagnostic analysis of individual group Notebook	Analysis of group patterns for sub-skills and behaviors
RQ1b		Examination of sub-skills and individual group behaviors	Discern behaviors that may contribute to group patterns of Notebook use

Diagnostic Summary of Student Work Samples: Patterns and Trends

Using information coded directly from student work sample Notebooks, scored on the rubric, and quantified with a coding checklist, trends in student use of the shared documents Notebook could be organized into three main patterns of student use, with pattern sub-categories that described these patterns of use in greater detail.

Did not use collaborative tool shared document. The groups evidencing this pattern fall into two categories; either they did not access the document at all, or they accessed it but abandoned use of the document. Potential reasons that they did not access it include not having the technology skills to recognize the resource or to know how to open it. Another potential reason is that they opened it but did not know how to "start" the use, which could be a technology based reason or an organizational/lack of collaborative skills issue.

Used the collaborative tool shared document but did not progress with task. Groups evidencing this pattern of use were able to access and use the shared document on a technological level, but did not use the tool to complete their assigned task. There appeared to be several patterns of behavior that led groups to fall into this category including lack of group organization; role or task conflict or confusion; off-task behaviors or topics; lack of visual organization; and poor relational skills.

Lack of group organization. The participants in these groups appeared and disappeared on the Notebook randomly. Some team member might post that they would take on a certain task, and never appear on the document again, to report their outcome. Someone else might post just a number or utterance, not seemingly connected to any other post or task. Participants may insert comments at the beginning, in the middle, or at the end of other existing comments, making it difficult to track group processes.

Lack of visual organization. Visual organization may or may not co-occur with group organization skills and evidence. Many groups were clearly engaged and posting ideas, questions, and resources, but the posts and discussion threads were clumped and intermingled stream of consciousness-style that made it hard to discern how threads were connected, who posted what, and how responses connected to queries. A clear visual format would likely have facilitated communication processes and task progress by conserving the energy necessary to wade through unrelated posts to track a thread.

The following excerpt is from one of three pages in a sample Notebook. Out of nine posts in a clump, four different clues are discussed or queried, along with two process questions and a prompt for participants to stay with their own identified font color. It must be noted that the color scheme per participant in the sample below reflects some advance skill and thinking regarding visual organization.

clue1 , i ..didnt write aything nad just skipped it ><
I am going to put barents sea... is that rite?
no I think it's the arctic basin
T-T ANYONE ON CLUE 3 YET?
nah.. we have an answer for 2? its snow isnt it!
wats . answwer to clue 1 . . . . .
what does all of this mean. D:
im on page 8 o-o how???
hahah how? and get off my colour!!!!

Figure 18. Notebook sample displaying trends in visual organization. The sample here does show emerging use of visual organization with the use of color for participants, but as described above, the participants did not all stick to a unique color, nor separate threads regarding differing clues or topics.

Role or task conflict or confusion. This pattern of behavior occurred primarily among the 11-year-old groups, and is characterized by participants attempting to organize the group by identifying and taking or assigning roles to group members. In these cases, groups used most of the document space on the conflict, without a real resolution. Evidence showed that the topic of who would have what role was very important to some members, to the extent that they could not engage in the actual task itself.

Poor relational skills. The student work samples did not reflect standard face-to-face norms regarding relational skills. A typical face-to-face group would include introductions and negotiation about roles, task assignments and workspaces. This could be transferred to a digital environment without too much difficulty once an instructor has planted the idea or formulated the structure. Some groups, comprised mostly of the more experienced 15 year olds, did display a transfer of relational skills by introducing themselves and claiming a "workspace" in the form of a font color or the use of initials and managing a task. That way, they could be tracked by others and responded to consistent with their posts. The group could track whether posted queries had been addressed or whether needs were persistent. They could also track who was participating and in what ways. There was some displayed need to preserve claimed identity when a participant said to another one who posted in his/her color "get off my colour."

Off-task behaviors. Some patterns of off-task behaviors or topics occurred in four groups, or approximately 12 percent of the sample. Off-task behaviors included digressing into affective topics such as how hard or difficult or frustrating the task was, but also included "messing around" as evidenced by typing random characters or engaging in back and forth off task comments such as seen in Notebook 4, shown in Figure 19.

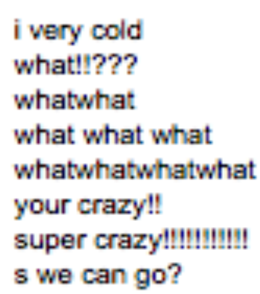

i very cold
what!!???
whatwhat
what what what
whatwhatwhatwhat
your crazy!!
super crazy!!!!!!!!!!
s we can go?

Figure 19. Notebook sample reflecting off-task behavior.

Used the collaborative tool shared document and progressed with task. This diagnostic category is difficult to completely assess by the student work samples as some of the better organized and complete work samples did not reflect stages of collaborative behavior. While there were vestiges of collaborative behaviors, the higher functioning groups appeared to "clean up" their shared document so as to present the participants and the co-constructed or collaborative answers. As one teacher-rater remarked "They didn't appear to realize that they were being graded on their collaboration—they were focused on answer generation and erased their collaborative evidence." The tracking itself could be better addressed in future assessments through the structure of the collaborative space, or the intermediate recording of work products, or both.

Some groups displayed what looked like collaborative activity between two or more participants, while other participants did not appear to show successful engagement in the task, thus making the group product less truly collaborative. While collaborative group members may have had cooperative learning strategies to employ, time constraints may have inhibited sustained efforts at group organization. One group had a participant who attempted to coach co-participants through a task, but gave up and responded to persistent queries for assistance from a group member with "never mind, it takes too long, I have made an answer for you, its easier" reflecting her frustration with using the system to help someone locate, access and use a tool in a remote-located situation. However, this also can indicate less skill development in the purposes and approaches to collaboration, where building shared understanding has the potential to improve the individual answer.

Interactive regulated learning and relation to collaboration. One pattern displayed was a relatively high degree of interactive regulated learning: evidence of seeking or offering help; reporting progress; clarifying process; self or group evaluation; time management; task orientation; goal setting; mediation; or appreciation, paired with sharing resources and content, but not progressing through collaboration or co-construction of knowledge.

These groups engaged in the process of collaborative work together, but did not harness collective efforts to complete the task. This could have been due to an initial lack of role or task assignment or even visual structural organization, as many Notebooks displaying group activity in collaborative processes lacked essential organization such as who is participating and what task will each do. It also could be due to the fact that collaboration and co-construction of knowledge require a) relational skills combined with b) task orientation and c) specific reciprocal interaction. This three-fold skill set may be developmentally challenging for students who have not had explicit instruction and substantial practice on this area.

Collaboration. The traits collaboration and co-construction of knowledge are the least displayed in the student sample shared documents. Only nine out of 33 sample Notebooks had ratings of "developing" skill for collaboration, and only two sample Notebooks had ratings of "capable" for collaboration. Yet the essential question that guides the analysis of the collaboration trait is simply stated "Did participants add to, evaluate, or offer an alternative response to the shared resources or content?" The requirement is to read a post by a co-participant/team member and add to it; disagree and state why; offer an alternative, preferably with rationale; or acknowledge the contribution with agreement. These are not inherently difficult tasks; even first grade students could practice such an exercise verbally, supported with concrete prompts. The performance levels of the sample student groups suggest that they were unaware of the protocol for collaborative learning, and may perform in more productive ways if this skill is taught.

Co-construction of knowledge. Co-construction of knowledge is more complicated. The essential question defining the trait co-construction of knowledge is

"Did participants use shared and evaluated content to construct final answers or responses or complete a task?" The difference between collaboration and co-construction of knowledge thus defined is negotiated agreement on a shared response (or idea or conceptual understanding, depending on the task) that is based on and negotiated from the collaborative input of group members, making new meaning or knowledge. Co-construction of knowledge involves the step of initiating a call for consensus or a joint frame. "We have several ideas and various perspectives about the effects of global warming on polar bears; how can we take this input and frame an answer?" The group must then play with the input and perspectives to decide what they can agree on to submit for a group response. Developmentally, this is advanced, and the sample Notebook scores show it; only four Notebooks showed "developing" status for the trait co-construction of knowledge, nine showed "emerging" status, and the other 20 samples were non-collaborative.

Skills necessary to perform co-construction of knowledge include an awareness of the skill and the steps involved; receptive and expressive communication skills; the ability to hold multiple perspectives simultaneously; conflict resolution/negotiation mediation skills; and open-mindedness to outcome or the ability to suspend ego-based attachment to collaborative contributions. Developmental psychologists would place the sub-skills necessary to engage in co-construction at late adolescent or young adult age, respective of individual developmental differences. Nonetheless, Vygotsky (1978) holds that socially mediated scaffolding of these skills would permit younger students, perhaps late elementary or middle school, to engage in co-construction in a highly guided context.

Results of Phase 5: Instructional Design

Instructional design elements were synthesized from the evaluation of student works samples and the qualitative responses of educators using Cognitive Task Analysis and Backward Design principles. This involves categorizing sub-skills into instructional domains or curricular content areas; Table 18 outlines the process.

Table 18

Phase 5 Processes and Outcomes

Phase 5: Examination of skill areas for Instructional Design	Method	Process	Results/Outcome
Phase 5.0 RQ3	Cognitive Task Analysis and Backward Design	Categorize skills per domain	Develop instructional categories to aid in planning and resource allocation

The analysis of composite skills for collaborative learning in a digital environment situated in a global education context for 21st century skills shows that three distinct skill areas, academic social-emotional skills, cooperative learning strategies, and technology, could allow for the possibility of success in digital collaboration. To meet best practices for 21st century skills and global education, the tasks lend themselves to embedding in an authentic, real work context to increase student engagement and facilitate transfer of skills. The model is illustrated in Figure 20.

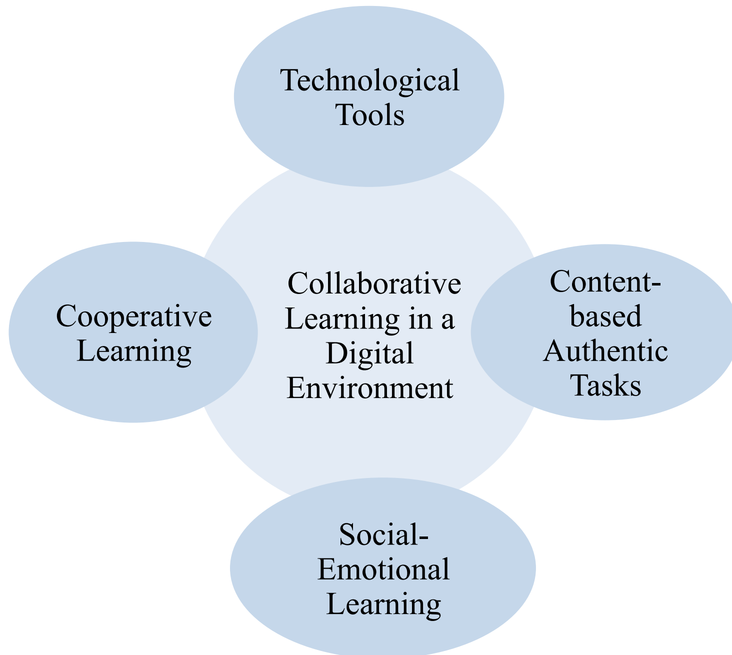


Figure 20. Elements for Teaching Collaborative Learning in a Digital Environment.

The skills used to develop the collaborative traits used on the student shared document Notebook fall into different domains: the use of the technology tools and the understanding of the digital environment; the academic social-emotional skills; content area skills such as decoding, reading comprehension, interpretation of charts and graphs, and the ability to estimate or perform basic calculations; and a grasp of basic cooperative learning principles with the practice necessary to organize task orientation and facilitate the metacognitive group processing that will help the group stay focused on task, with all participants engaged.

Technology Skills

Technologically, some students may not have understood the links, may not have known how to open the document, or how to write on it. A Google document saves automatically, so knowing how to save work is not immediately necessary, but students had editing functions, so any student could have erased any other students' work, by accident or intentionally. While there is a function to recover former iterations of a document, students may not have known how to access or use that function. Several Notebook entries referenced not knowing how to access a link, not understanding how to use a function, having just found the Notebook document after much confusion, admonitions to stop erasing from Notebook, or trouble loading pages that held information for the Arctic Trek clues.

Academic Social-Emotional Skills

This assessment scenario involves functional academic social-emotional skills such as turn taking, communication, self-regulation, negotiated or interactive regulation, and perspective taking. Other related skills such as empathy, self-awareness, dealing effectively with conflict and decision-making skills would also be necessary for successful negotiation of this collaborative task.

Cooperative Learning Strategies and Skills

Students who have frequent classroom practice in cooperative learning strategies may have some automated responses when groups are formed to facilitate completion of an assignment. Typical automated responses from adequate training in cooperative learning techniques might be organizational processes such as role assignment and task assignment. Familiar cooperative learning roles that promote group mediated or interactive group regulation includes timekeeper, someone who will serve as recorder, someone who will ask clarifying questions, and someone who will ask process questions.

Shared document skills. As the use of shared online documents is relatively new, it is not unexpected that this skill would be emerging for most groups. The most successful groups would likely transfer their skills in academic social emotional learning and cooperative learning to this technological medium. Adaptation would be necessary to overcome the dependency on face-to-face interactions, and strength in social-emotional learning skills would be one way to accommodate the lack of vocal, facial, and postural cuing. One method students used to adapt their social-emotional skills in sample Notebooks was with the use of emoticons and social text-speak.

The ability to communicate effectively and work collaboratively in a remote-located shared document space is an important 21st century educational and workplace skill. Many universities use shared document work in online or hybrid courses, and businesses use this venue to facilitate work across time zones and locations, saving both human and finite resource energy by allowing individuals to contribute no matter where they are relative to the project home. The project home may be online or cloud-based with project ownership shared between many participants; this assessment task attempts to recreate the authenticity of real world adult skills.

Composite Domains Supporting Collaboration in a Digital Environment

Academic social emotional skills, cooperative learning skills, and skills in using technological tools are necessary for the ability to be successful in a collaborative learning task in a digital environment. Each of the skill areas is multi-dimensional, itself a composite of many sub-skills; these are shown in Figure 22. Academic social emotional skills are the essential building block due to how these basic skills support successful use of cooperative learning strategies. Technology or ICT skills could be taught or learned in an individualistic manner, but without training and practice in the academic social emotional area, it may take much time and effort for obstacles to be cleared in a collaborative context. Overlaid on these curricular component areas are basic skills in core content areas. If a student has all the requisite academic social emotional skills, cooperative learning training, and knows how to work web 2.0 tools but has poor reading skills, his or her participation in remote-located collaborative environments will be challenging.

In the student work samples evaluated for this assessment, many groups did not use the skill identification, or set up some sort of system for coding responses per participant. In general, they did not make task assignments, though some groups attempted this and in other groups individuals volunteered to get started on something specific towards the shared goal. There was a general lack of discursive reciprocal follow through with most groups. A participant may make a request or ask a question, but not receive a response; this may be followed by a completely different request or response, reflecting discontinuity within the group, such as excerpted from Notebook 2 as shown in Figure 21.

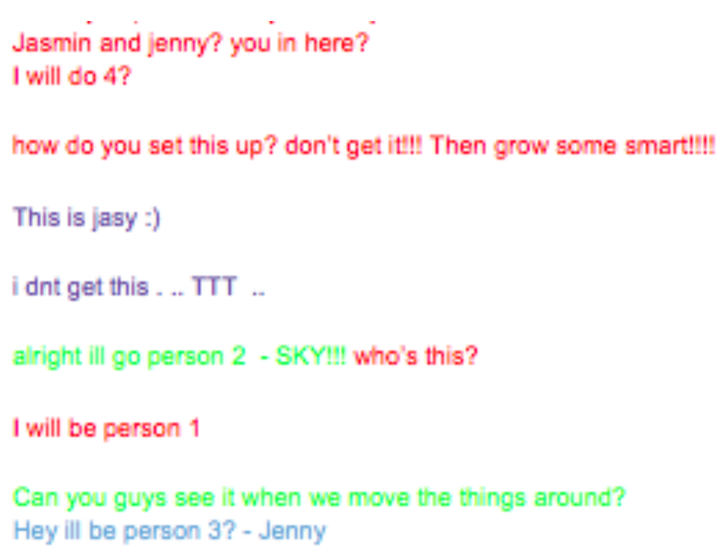


Figure 21. Notebook sample illustrating lack of reciprocal discourse.

It is impossible to know whether this behavior would hold true for the same group in a face to face setting, but it is not uncommon for school age students to not fully listen to one another or address each other's concerns, which links to fluency in academic social-emotional learning skills.

Each component area of collaborative learning in a digital environment has skill sets that necessitate teaching, practice, and environmental supports; see Figure 22 for an elaboration of the domains elated to digital collaboration and their relative component sub-skills.

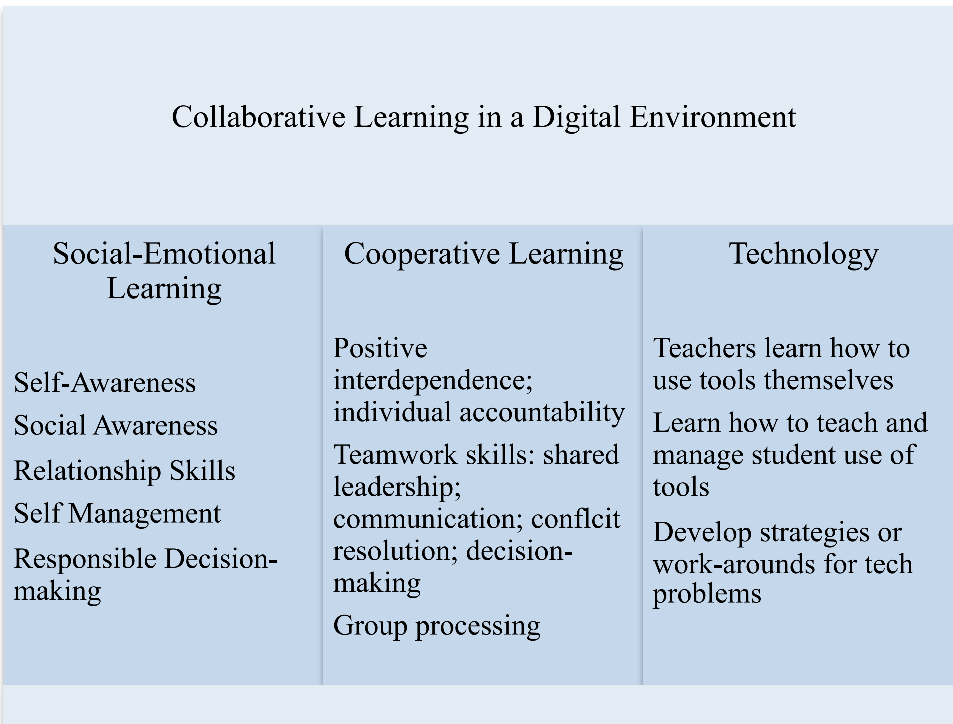


Figure 22. Curricular Components of Collaborative Learning in a Digital Environment.

Curricular progressions exist for these components, as explicated by frameworks for these areas. Many states have adopted standards for both social-emotional learning and technology/ICT literacy. The curricular components do not need to be sequentially taught, though social-emotional skills are the foundation for success in cooperative learning. It is possible for these skills to be presented in an integrated manner and associated with authentic tasks. One example of this is was designed by a 4th grade teacher using technology to create shared documents in cooperative learning groups around the task of creating classroom norms and rules. This teacher prompted students to structure their shared document space with color-coded identification to share their ideas within a group. They posted their group results in a shared digital space and used the collection of shared documents to find the commonalities between groups and as discussion points in developing class rules for the year.

Results of Phase 6: Professional Development for Digital Collaboration

Professional development needs are described from the instructional design elements and from the qualitative responses of educators regarding the student work samples, rubric use, and perceived preparation to teach the sub-skills necessary for success in the overall ICT literacy task. Educators were surveyed regarding professional development in the areas of collaboration and technology. Table 19 provides a description of phase six activities.

Qualitative feedback on professional development needs was obtained from teachers in rubric rating session. Teachers reviewing the rubric and evaluating Notebook samples reflected a diverse group of educators, trained in a variety of disciplines, including Mathematics, Biology, Music, English Language Arts, Elementary Education, Economics, and Psychology. They had varying time frames for their own teacher preparation programs, with three teachers earning credentials in the last ten years, and the rest having worked in the field between 20 and 33 years. All use the Internet at home and school, conduct business through email, and engage in some sort of social media use. Only three of the eight had limited exposure to Google docs or other online collaboration tools, and no one considered himself or herself proficient.

Table 19

Phase 6 Processes and Outcomes

Phase 6: Investigate potential professional development strategies	Method	Process	Results/Outcome
Phase 6.0	Needs Assessment	Survey educators re professional development	Discover common experiences and needs
	Qualitative feedback	Educators reflect on use of technology and collaboration	Generate information re task specific needs

Educators discussed their need for professional development in relation to both learning the technological skills necessary to engage in digital collaboration themselves, as well as for training in the instruction of these skills for their students. Additional professional development needs were cited for how to use these skills in a classroom setting, and how they could be integrated with existing curricular demands, or if they would be better taught in isolation. There was some concern about site-based support for maintaining the technology necessary for instruction in this area.

Some raters observed that many newer teachers are no longer trained in cooperative learning methods as had been popular in the 1980's and 1990's, and that instead teachers are trained in data-based decision-making and assessment, so experience teaching cooperative or collaborative behaviors may be lacking among many educators.

Educators serving as inter-raters also took a short demographic survey regarding their years of training and grade level experience; professional development in technology, cooperative learning and social-emotional learning; their personal and professional use of both technology and collaboration; and their exposure to 21st century skills, specifically if they had seen or could identify a 21st century skills framework. The survey can be seen in Appendix N, and the results of the survey raters in Table 20.

Table 20
Survey Results: Professional Development in Technology and Collaboration

Years of Teaching	PD in Technology	PD in Cooperative Learning	PD in Social-Emotional Learning	Familiar with 21st Century Skills Frameworks	Personal Experience in Collaboration with Technology
7	No	No	No	No	Yes
8	No	No	No	No	No
10	Yes	Yes	Yes	No	No
11	Yes	Yes	No	No	Yes
19	Yes	Yes	Yes	Yes	No
20	Yes	Yes	Yes	Yes	Yes
21	No	Yes	No	No	No
33	No	No	No	No	No

When asked about the use of collaborative work in a technological setting with their students, six out of eight educators replied they lacked sufficient technology, while two said they felt their students were too young. Teachers reported that they lacked time due to other curricular needs; and that they don't feel proficient or have the confidence to teach these skills. The raters who reported using collaborative work in a digital setting professionally primarily referenced wikis or blogs, and everyone added the caveat "not much" to their level or frequency of professional use of technology.

As a related comparison, most of the 40 participants in a UO graduate level course in Information Technology in the summer of 2011 were introduced to Google docs and other technological collaboration tools such as wikis or social bookmarking sites for the first time, though they were seasoned educators and administrators enrolled in a masters or doctoral program in Educational Leadership. This lack of experience and training in technology was not specific to teachers living proximal to the University of Oregon; about half of the class was from Canada attending a master of education program. Such information helps to underscore the need for technology preparation for teachers.

Analysis of Results and Validity Considerations

Validity is used here as an evaluative summary of the evidence for and consequences of score interpretation through the degree to which empirical evidence and theoretical rationale support the interpretations and the use of the assessments or implications for action (AERA, 1999; Messick, 1995). Rather than being a property of the instrument, validity is the meaning of the scores as a function of the items and the people taking the assessment and the context of the assessment. Kane (1992) suggests using a unified argument-based approach to validity, conceptualizing validity as an argument with the interpretation of test scores supported by evidence being evaluated against competing interpretations and potential counterarguments until the latter are refuted. Messick (1995) describes validation as a continuing process and suggests constructing evidence supporting the intended purpose of the assessment as the first step in creating a valid measure.

A series of validity considerations were addressed in this study through the following approaches:

Construct Validity

One possible threat to construct validity in this study was construct confound, including construct irrelevant variance (CIV) (Haladyna & Downing, 2004; Shadish, Cook, & Campbell, 2002). Messick (1996) discusses richly contextualized performance assessments and authentic simulations of real world tasks to be at risk for CIV due to contextual clues, but considers that risk ameliorated by the construct relevance of the clues. Messick also delineates the difference between a construct confound type CIV, and the use of higher order constructs where complexity is required to subsume or organize multiple processes and have various constructs operationally required at the same time. Determining whether a source of variance is a relevant part of a focal construct or simply a confound is key to avoiding CIV and maintaining construct validity in this situation.

Construct Irrelevant Variance increases in highly contextualized tasks such as the Arctic Trek performance assessment due to the aforementioned use of higher order constructs composed of many sub-skills, which in the Arctic Trek assessment task included technology skills, academic social emotional learning skills, and collaborative learning skills, as well as content-based skills such as math and reading. ATC21s assessment developers took great care to succinctly define and operationalize constructs and match content to grade level standards, but it remains likely that the reading numeracy and other skills of individual students interfered with their ability to be adequately measured on the collaborative process and product constructs embedded in the assessment.

For ATC21S, a sampling design was used over a set of tasks, work products, and group settings in order to address this concern and establish validity for the ATC21S intended inferences of digital literacy assessment *over a set of uses for collaborative digital literacy in learning situations*. However, it must be noted that this dissertation study selected only one a single work product within a single task so exploring the wider implications of the sampling design are outside the scope of this research. Therefore this is a limitation of this study of a small segment of the data.

Domain theory and structure. Domain theory is the primary basis for specifying the boundaries and structure of a construct for use in the development and scoring of performance tasks and can be accomplished through task analysis or curriculum analysis (Messick, 1996). Specifying boundaries includes determining the knowledge, skills, attitudes, motives and values, such as ATC21s has outlined in the KSAVE model that is used for both task delineation and scoring on the Arctic Trek assessment. For each element of their 21st century skills framework, as discussed in Chapter I, (Ways of Thinking, Ways of Working, Tools for Working, Living in the World, and Digital Learning Communities), the KSAVE model describes sub skills categorically divided between the (1) Knowledge; (2) Skills; and (3) Attitudes, Values and Ethics needed to master the framework element.

The sub skills are elucidated specifically with detailed, measureable descriptions. Refer to Appendix C to see the tables for Tools for Working and Ways of Working, the two ATC21S framework areas addressed in this dissertation. Functional importance, or ecological sampling increases construct relevance and validity by considering both what people do authentically in the performance domain and also what characterizes and differentiates expertise in the domain (Messick, 1995). The ATC21S group has richly simulated actual networking performance, assigned specific skills to each construct, and established a three to four level range for expertise across representations, as shown in the blueprinting process in Appendix A and B.

Process models and engagement. Process modeling assists with the identification of domain processes to be revealed in the assessment tasks (Messick, 1995). The tasks must provide appropriate sampling of the domain processes while covering domain content as well as evidence of participants engaging in task performance in order to capture performance consistencies demonstrating domain processes. Sources of process-based evidence might be from think aloud or self-talk protocol, computer modeling of task processes, or correlation patterns among part scores, (Messick, p.745). The Arctic Trek assessment incorporates rich representative sampling of domain processes allowing ample opportunities for students to demonstrate their performance. The assessment also engaged in extensive Cognitive Laboratory process evidence, not described here as outside the scope of this dissertation data set, with extensive in-person observational protocols in each country, as well as video showing students taking the assessment, screen shots showing keystroke choices and curser navigation, and think aloud verbalizations; the self-talk component was introduced to students as part of their preparation for the assessment during the cognitive laboratory process. Teacher training materials and the Assessment Delivery Booklet used by assessment administrators are also available, showing the degree of standardization in the process of assessment delivery.

Scoring models and correlations with external variables. The cross scoring of assessments with diverse models can highlight the assumptions and values of each method (Moss, 1996). Messick (1995) suggests looking at assessment score relationships with other measures and even non-assessment behaviors to check the interactive relations within the construct. Finding evidence of a link between assessment scores and criterion measures validates the scores for providing meaningful information about the construct. Criterion validity efforts included the comparison of student scores across numerous tasks and work products, and in different team arrangements. This data set is outside of the scope of this dissertation as well, but is mentioned here regarding the assessment development process more generally.

Selection Bias and History

Some threats to validity in this study were selection bias and history (Shadish et al., 2002). The participating students were not randomly sampled, and though there were attempts to include students representing different regions, socioeconomic status and ages, there were unknowns about the variance in experience with the constructs measured across the student sample. There was uniformity in both teacher training for preparation and administration and in the administration procedures during the assessment, with direct observation for fidelity to the model. However, the very small sample size and generative nature of the task development requires caution in interpretation of the results, as does the cross-case analysis on a limited number of comparison cases.

External Validity

Threats to external validity include the generalizability of the findings to other students and school settings. The degree to which the results will be generalizable to others is affected by a variety of factors. Sample selection bias could be introduced by using samples based on convenience, clustering, and self-selection (Alreck & Settle, 1995). The degree of variation in the sample and small sample size could also jeopardize external validity. Due to the timing of the collection of pilot data for the ATC21s project, a small sample was used. Within-sample variance on school site characteristics, grade level, content exposure and opportunities for skill development could provide sampling error, as according to Alreck and Settle (1995), the more the variance that exists in the sample population, the greater the possible sampling error. Sampling bias or poor representation could lead to sampling error and thus weaken the external validity. Context-dependent mediation is another threat to external validity, as student performance may be affected by novel situations and may not accurately reflect their true performance estimate (Shadish et al., 2002).

The data set used here was part of a small pilot study of the tasks. Larger field trials are currently ongoing in several countries, and will help address some of these issues, but are outside of the scope of this dissertation.

Statistical Conclusion Validity

According to the *APA Standards for Tests and Measurement* (2002*)*, analyses for some of the questions in this study are appropriate for descriptive statistics, but the small, non-random sample will be predisposed to Type 1 and 2 errors for inferential statistics, which therefore are not used here for this emergent stage of the work on these assessment tasks (Shadish et al., 2002). A small sample was used due to time and cost constraints in piloting new assessments, and due to the descriptive nature of the research questions that employed the cross-case qualitative Body of Work method, a “thick description” technique that focuses on patterns and themes in a smaller number of samples rather than inferential aggregation over a large data set. The use of inter-raters in reviewing student Notebooks helps guard against Type 1 error in the descriptive comparisons, as evidence will be cross-coded and independently categorized, and the multiple lenses of the iteration with both qualitative and quantitative data will assist in interpretation of results.

CHAPTER IV

DISCUSSION

The purpose of this study was to examine student work samples from a collaborative performance task in a digital environment and describe any patterns or trends of collaborative skill evident in the body of work. The intent of this study was to contribute to research that may inform practice for instructional and assessment strategies in this emerging area of collaboration in a digital environment. This study hoped to contribute to the research on digital collaboration in education in four key areas: a) further the understanding of the cognitive and social processes involved in collaborative digital literacy skills for students at ages 11, 13 and 15; b) help inform instructional leaders on conceptions of student work in virtual collaboration; c) contribute to the dialogue of instructional design to support collaborative learning in K-12 education; and d) offer considerations for formulating professional development. This study had an additional intent of contributing to research methods by providing an example of a mixed-methods, multi-dimensional, multi-phase iterative design to organize qualitative data for analysis and interpretation such that this type of data, exemplified by the student work samples, can be adequately transformed to information useful for data-based decision making in K-12 systems.

This chapter is divided into six sections. The first section presents summary conclusions with respect to the research questions and hypotheses. The second discusses the contributions this study makes to the body of knowledge for research and practice in the field. The third outlines areas for future research. The fourth discusses the limitations of the study and threats to internal and external validity. The fifth section addresses the implications of the study and results; and the final section offers conclusions.

Research Question Summary

This study examined collaboration in a digital environment during a performance assessment of 21^{st} century skills among 11, 13 and 15 year old students. The results of this study appear to fill a unique niche that bridges research in technology and collaboration with concerns of practice situated in K-12 settings. There are three outcomes related to this study: a) an examination of trends and patterns in student collaborative ability; b) the development of a rubric that can be used as a prototype or guide towards measuring collaborative learning in a digital environment in K-12 settings; and c) an analysis of sub-skills needed to support collaborative learning and the curricular domains in which they are housed to inform instructional design. This study was designed around three research questions, which are described below with the results of the analyses.

Research Question 1:

1. Does the use of the artifact Arctic Trek collaborative Notebook fall into distinct patterns that reflect levels of skill development or show trends in collaborative learning through a digital environment?

1a. Can categorical patterns be identified?

1b. Can these patterns be seen as types of performances referenced by collaboration literature?

The results of this study suggest that student use of the collaborative document Notebook do reflect levels of skill development, and that categorical patterns of collaborative skill can be identified. The patterns can be categorized by the following trends: a) slightly higher skill with collaborative processes over generating collaborative products, and b) skill development reflective of non-collaborative or emergent levels of skill.

The overall trend of displaying non-collaborative behaviors is affected by the number of groups who either did not access their shared document Notebook, or who abandoned it after limited use, scoring a zero on the 3+3 Six Traits Digital Collaboration Rubric that was generated by the body of evidence from the samples and then used to measure student work samples. The study lacks sufficient background information to ascertain whether students lacked technological skill to access or use the Notebook, did not understand assessment directions, or simply made a choice not to work with their group.

Of groups who accessed their Notebook and displayed emerging skill in collaboration, the easiest skills or traits to display were identification or role assignment, interactive regulated learning (asking for and offering help, reporting progress, clarifying processes, time management, task orientation, goal setting, and self or group evaluation) and sharing or reporting content. These would seem to be familiar and relatively easily transferable skills from classroom or even non-instructional situations. The more difficult traits to display were co-construction of knowledge and collaboration; these are skills that the students may not have had prior exposure to or experience with.

Some of the patterns identified in this study are similar to those referenced in the literature on collaboration. Literature referenced for this component of the study was primarily that of Computer-Supported Collaborative Learning (CSCL), which has varied and divergent focal points and methodologies, and largely examines university-level students, so studies that closely match this project are few (DeWever, et al., 2006). The type of content discovered through discourse analysis in this study supports the research of Gunawardena, Lowe & Anderson (1997) who described five phases of knowledge construction:

1. Sharing or comparing information
2. Dissonance or inconsistency
3. Negotiating agreements or co-construction
4. Testing tentative constructions
5. Statement or application of newly constructed knowledge

They found that phases 1 and 3 were dominant and phases 4 and 5 occurred less often. Through both task structure and qualitative analysis of the sample Notebooks, this study showed all of those elements to be present in student discourse, and that sharing or comparing information was one of the traits displayed frequently in student work Notebook samples.

Research Question 2:

2. Will descriptive analysis show that levels of Notebook use have a relationship with student age, for this sample?

2a. Can data displays show if and how patterns may cluster by age?

2b. Are there important trends to be seen in the age-related patterns, such as will more advanced digital collaboration patterns be seen for younger or older students, in this data set?

My hypothesis was that I would find patterns associated as trends, and that they would have a relationship with age. The results of this study show only a slight trend in increased digital collaborative ability by age. Due to the small sample size with uneven age distribution, generalizations cannot be made, but overall in this sample the 15 year olds presented a slightly higher mean score on the 3+3 Six Traits Digital Collaboration Rubric at 6.2, while 11 year olds presented a mean of 5.7; with a total possible score of 18 points, no age group demonstrated beyond on average emerging collaborative skill when measured by the rubric.

This assessment of collaboration in a digital environment is un-instructed—and therefore more formative in nature and not necessarily reflecting an opportunity to learn. Older students have naturally had more experience in school, such that the higher the grade level the more overall access students have had to technology, content skill, and teamwork situations. The four years of schooling experience and societal exposure that 15-year-olds have beyond 11-year-olds can likely explain the slight gain in mean score. Additionally, age 15 showed fewer cases with a score of 0, perhaps reflecting more refinement at carefully following instructions or showing responsibility in classroom situations. The 11-year-olds showed less volume of social discourse in their Notebooks as per qualitative analysis, and were the only age group to engage in substantial amounts of role conflict, which demonstrates perhaps some psychosocial differences between the two age extremes of this study.

Research Question 3:

3. Given the results of analysis in RQ 1-2 above, do performance patterns identified in the digital collaborative work products suggest connections to student instructional support, as examined through an instructional leadership focus?

The results of this study identified performance patterns in the digital collaborative work products that suggest instruction in the components of digital collaboration may enhance student performance. As there is not a widely available curriculum for such instruction in digital collaboration as a subject, component areas could be detailed and used for instruction to strengthen sub-skill areas until comprehensive curricula exist specific to the processes involved in digital collaboration.

A program of instruction needs to be designed to teach the array of concepts and skills needed for students to be equipped to engage in collaboration in a digital environment. Effective instructional design will need to take into consideration necessary developmental frameworks that are aligned with readiness and ability across physical, cognitive, and social-emotional domains, and aligned both vertically across the developmental spectrum and horizontally to tie into other key areas of conceptual and skill development. Such frameworks would need vetting and trials within the applied instructional setting to determine their accuracy and value.

As 21st century skills are not necessarily content-specific but span traditional domains, creating models for multi-disciplinary integration or inter-disciplinary opportunities may be essential for the infusion of these skills within K-12 settings (Klieman, 2004; Pecheone & Kahl, 2010). Educators, especially in middle and high school settings where students may be more developmentally ready to engage in collaboration through digital environments, are largely compartmentalized, and have content-based frameworks and standards to address along with high stakes testing accountability measures (Harris et al., 2009). Providing easily implemented activities or exercises that apply 21st century skills towards learning discipline-specific content can facilitate inclusion of such skills as digital collaboration (Inan et al., 2010). The new U.S. common core standards allow for substantial integration of cross-cutting and higher order skills into the traditional domains (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010).

Development and testing of assessments for collaborative ability will be important for the support of including this type of instruction in K-12 settings, which are accountability-driven (Hew & Brush, 2007). The ATC21S performance assessment Arctic Trek could be redesigned to include an ill-structured element to promote possibilities for collaboration on shared meaning and co-construction of knowledge. The assessment could also more explicitly state the purpose as assessment of collaboration, provide a model of such, perhaps a video or think-aloud as part of the assessment instructions, or provide some type of format that structures or mediates the group interaction. The samples of student work from that revised assessment could be examined to determine whether students showed an increase in collaborative skill over these initial trials.

Contributions to Research and the Body of Knowledge

Despite the limitations of the study, this work makes potentially significant contributions to the field of CSCL or broadly digital collaboration or collaboration and ICT Literacy in a sub-category of the field that is not widely studied: practical applications to K-12 educational settings. This section discusses previous studies in the literature and compares their suggestions for further research with the results generated by this study. Contributions can be outlined as follows:

This study

- Addresses issues specifically called for in the research community
- Examines digital collaboration with this age group, unmediated, in a performance assessment task, currently a unique sample in the field
- Describes patterns and trends of student skill displayed in a digital collaboration task
- Analyzes sub-skills necessary for success in digital collaboration
- Explores Instructional Design for implementation of digital collaboration
- Considers Professional Development needs for instructional preparation
- Charts a methodology for organizing and analyzing collaborative student work samples
- Provides an example of a multi-phase iterative methodology to bring information from student work through task analysis and into instructional design.

This study is somewhat unique in that it is one of very few studies of digital collaboration among K-12 students, and where students of these ages are remotely located and using a collaborative document. Other studies of digital collaboration in a K-12 setting include a scaffolded, mediated digital collaboration with small groups of middle school students solving math problems (Stahl, 2006); scaffolded instruction in collaboration with middle and high school students in face-to-face classroom environments where groups were supported and mediated with a digital collaborative script (Nussbaum et al., 2009); and face-to-face cooperative learning groups studied for performance differences in mediated versus unmediated groups (Gillies, 2004). This study adds to this body of work.

Rotherham and Willingham (2009) discuss curriculum, teacher expertise and assessment as the main challenges for the integration of 21st century skills in the schools. The researchers advocate for a long-term iterative process of planning, implementation, reflection, and continued planning, with implications for teacher training and curriculum development. This study addresses these challenges, exemplifies the iterative model, and offers an iterative organizer for a model of Professional Development as illustrated in Figure 24 located in the section 'Implications for Professional Development', in this chapter.

Researchers in the field suggest examination of diverse groups and situations using CSCL to help develop instructional practices that enhance virtual collaboration as an educational tool and increase the understanding of the psychosocial processes in the problem solving space (Strijbos et al., 2004a). This study contributes to the body of knowledge with regards to students ages 11 through 15 and helps to develop instructional practices for virtual collaboration through the analysis of domains and sub-skills involved in virtual collaboration, as well as the initial attempt at designing a rubric to guide instruction and measure student progress.

Hew and Brush (2007) identify current knowledge gaps as including teachers' content and pedagogical knowledge for integrating technology in relationship to a curriculum, specifically strategies for integrating technology into various subject areas.

This project analyzed a demonstration of collaborative student work where students used a shared document as a collaborative tool while searching for content to use in a problem-solving space. The format and structure of this task could be utilized across disciplines, and adjusted to become more open-ended or ill-structured as suggested by literature to best promote collaboration.

Hew and Brush (2007) also suggest research examining cooperative group work in a technological medium to 1) identify how a teacher would structure the task, and 2) illuminate the obstacles involved in such strategies, leading to guidelines for instructional design so teachers and instructional leaders can make informed decisions about how to employ these strategies. This study examined that type of work and provides the following to advance the body of knowledge: 1) explicates trends and patterns of student behavior in a technology-based collaborative task in such as way as to inform teachers of instructional issues and obstacles; 2) provides an analysis of sub-skills needed for increased student success in such tasks; 3) offers a rubric to guide the organization of instruction, and 4) suggests elements to consider for instructional design for both student collaborative work and professional development for teachers.

Rotherham and Willingham (2009) describe uncovering the implicit domains involved and discerning sub-skills that can be taught to support 21st century skills as a significant contribution to methods for teaching 21st century skills. They suggest that this could lead to targeted professional development for educators to become proficient in and prepare for teaching such skills. This study addresses specifically the areas of implicit domains and sub-skill analysis and suggests areas for targeted professional development based on surveyed needs, as well as a professional development model based on the literature for best practices in professional development for school improvement.

Through a blend of what Stahl et al. (2006) define as experimental and descriptive CSCL methodologies, this study utilized seeking patterns in data to uncover behaviors and understand in very broad terms how the general practices work. The researchers explain that descriptive examination offers the opportunity to discover both how groups accomplish effective collaborative learning and also how they fail to do so.

Finding cases where interactional accomplishment of learning is absent, and seeking to determine what aspects were missing or contributing to this lack of collaborative learning is an important research effort, while being open minded about what else of value might be accomplished by the participants in lieu of the collaborative learning as student work is reviewed (Stahl et al., 2006). This study found the following behaviors that appeared to interfere with collaborative work: poor virtual relational skills including inefficiency establishing participant identity and role or task confusion or conflict; frustration with the technological medium; lack of group organization; lack of visual organization; and concern regarding time constraints. Additional behaviors that appeared to interfere with performing collaborative work include students not fully understanding the concept of collaboration, or perhaps not having sufficient requisite sub-skills such as perspective taking, negotiation, or decision-making, most likely in the absence of specific instruction on many of these skills.

Areas for Future Research

This study illuminates the need for additional research to further explore the performance of rubric components across task types; aspects of communication among students in this age range; the effects of changes in venue or format from digital to face-to-face settings on collaborative skill; the variables associated with digital collaboration identified through this study; social-emotional based perceptions of collaborative work; digitally embedded metrics for ongoing assessment of student work and increased utility of shared document spaces; and professional development and school site infrastructure needs to support instruction in digital collaboration.

Further research on the 3+3 Six Traits Digital Collaboration Rubric could include investigating the utility of the rubric with other tasks, specifically gathering data to describe the skill areas that could be optional in different tasks, such as role planning. This would increase the usefulness of the rubric and allow for wider use of the rubric with collaborative tasks across content areas and grade levels. The rubric could also be tested on a similar task with a greater sample of teachers to better ascertain how it performs as an assessment tool and instructional guide.

Another area of study might be the lack of thread development and reciprocal communication among students of this age range to determine whether the digital environment contributes to this phenomenon, or whether there may be generalized difficulty executing reciprocal communication across environments. Comparison studies could examine the use of scaffolding or mediated communication on thread development and reciprocal communication among students, with extensions to whether sustained scaffolding results in transfer of the skills.

A format comparison study of a digital collaborative task as compared to face-to-face collaboration on the same task, could describe where, how, and if transfer of face-to-face skills occurs in a digital environment, and to examine which, if any, of the face-to-face skills are either not necessary or inhibit collaboration in a digital environment.

Changes in the process of the digital collaboration task could be studied for a broader understanding of digital collaboration, including the effects of structuring or scaffolding a comparable digital collaboration task among similar aged students to see if the mediation would promote a greater display of skill; the results of a similar task in digital collaboration after students had received instruction and practice in this area; and the effects on performance in a parallel digital collaboration task for similar aged students that was ill-structured and thus more conducive to co-construction of knowledge.

Research to advance the understanding of development of collaborative skill could identify variables for the rubric that might affect collaboration skills, such as i) group facilitation by a teacher, more able peer such as an appointed leader or reciprocal leader, as compared to no facilitation; ii) scaffolding of collaborative tasks; and iii) group size. A variable analysis could be done next from the trait information realized from the case analysis, using either the traits or the two dimensions of process and product as variables.

The construct Interactive Regulatory Learning could be examined for possible optimal ranges of activity that assist the process and facilitate a product, with notice to possible interactions between the amount of IRL activity and productivity; for example, as regulatory work goes up to assist process, is there a point at which the product work stalls or decreases?

A study of social-emotional processes might look at how students perceive the collaborative process: do they have a preference for collaborating with others or working independently, and what factors do they identify for their preferences. Would students who had instruction and practice in collaboration have different perceptions from students with less experience or from uninstructed settings?

Educational researchers could collaborate with software developers to investigate the possibility of Embedded Analytics within the shared document structure that could build items from the scoring rubric into the digital environment in an automated way to increase the ease and facility of monitoring student progress in skill development, and look at use patterns of the shared document features towards enhancing use through format modifications.

Areas warranting further examination regarding professional development include a needs assessment of a large sample of educators and of the settings within which instruction is situated. A needs assessment of teacher ability to support collaboration in a digital environment will need to include at minimum technology proficiency; knowledge of appropriate pedagogical strategies for teaching technology use to student of different ages and abilities; instructional capacity in the domains and sub-skills that support the development of collaborative skills in students; and knowledge and ability with instructional design principals to adequately integrate digital collaboration in multi-disciplinary contexts.

Educators prepared to teach such 21st century skills as collaboration in a digital environment cannot do so without the necessary site capacity regarding equipment and connectivity, of course. While such aspects of the digital divide are outside the scope of this research, it should be noted that technology infrastructure and planning analysis at a site or district level is warranted. Within the current economic climate, technology sustainability is a challenging goal for schools, though this may change substantially if digital devices such as digital books replace paper-and-pencil technologies in schools as new materials are adopted that are less expensive in the digital format. Schools should look for opportunities to include open-source and ubiquitous technologies into the classroom as appropriate, and where cost-savings can be made to achieve the possibilities through the materials available in schools.

Results of the study indicate that teachers may not have sufficient preparation necessary to teach to the component skills of social emotional learning, collaboration and technology and provide essential instructional support for students in these areas. These findings point to further research not only for the development of instructional design to incorporate these skills in K-12 programming, but also for professional development in both pre-service and in-service educators.

Limitations of the Study

This study has numerous limitations related to sampling and the measures, as well as internal and external validity, as discussed subsequently in this section. A detailed analysis of validity concerns is addressed in Chapter III beginning on page 141. Despite limitations referred to here, the results of this study provide useful information for an initial examination of the components of this study towards practical application in K-12 settings. The key to working with the limitations is to maintain the frame of the preliminary exploratory nature of this study, and not attempt to generalize the findings widely beyond what is warranted.

Limitations of the Sample

The sample is limited by its size and the sampling procedure. The sample size of 33 groups may be sufficient for a small formative survey of skill development of collaboration in a digital environment, but is too small to make broad generalizations or examine subgroups for behavioral patterns. The sampling procedure was not random. It involved researcher invitation extended to schools with personnel known to the researchers, which could create bias. Effort was made to get a purposive sample, with lower and higher students in digital literacy by the countries; however schools selected on the basis of providing sufficient technology also may have limited this range.

There was also sampling across countries for the cases, which introduced differences but not uniformly throughout the sample. Overall different and inconsistent conditions across school samples with regards to technology access and practice, SES, nationality, setting, or configuration also contribute to this lack of sample uniformity, and such international characteristics were not entered into the trend analysis due to insufficient and non-representative data sets.

U.S. educators from the field were employed as inter-raters, and were also surveyed regarding professional development and training in domains related to collaboration in a digital environment. While their contributions were essential to the study, they also exhibited sample limitations regarding sample size and procedure. The sample was comprised of 8 educators, with a sample of convenience drawn from both the local school district and remotely located purposively samples rural educators and one inner city educator. The educators had a range of years in the field from 7 to 33, and only one was male. Nevertheless, when taken as a snapshot for possible professional development needs and educator assessment of student work, the educator input provides direction to the query of whether this rubric will behave similarly across raters, and what training or experiences educators need to be prepared to teach 21st century skills.

Limitations of the Measures

The two measurement instruments used in this study, the Arctic Trek Performance Assessment task and the 3+3 Six Traits Digital Collaboration Rubric, have limitations associated with both their content and processes.

Arctic Trek content. Educational activities can be designed to encourage and structure effective collaborative learning by presenting open-ended or ill-structured problems requiring shared deep understanding (Stahl, 2009). Arctic Trek did not entirely provide this ill-structured cognitive environment and hence was not truly conducive to collaborative learning as defined by the research community of CSCL. Instead, the tasks were well structured with clues leading to a set of pre-defined answers, thus rendering co-construction of knowledge unlikely as students were comparing answers extrapolated from pre-defined content instead of generating original content. However, the information foraging, creation of digital tools and other activities in the broader tasks did involve considerable knowledge construction.

Complexity of skill interaction and student ability. It is possible that student ability in non-assessed content areas such as reading/decoding, reading comprehension, or math and science skills such as interpreting graphs and charts interfered with student ability to participate in collaboration. Similarly, students who were not fluent in technology or who had never accessed or utilized a collaborative document prior to this assessment may have had their opportunities to participate collaboratively curtailed due to this lack of fluency.

As discussed in the literature review, complex sets of academic social-emotional skills interact to culminate in multi-faceted collaborative problem solving and co-construction of knowledge. Sub-skills necessary to enter the process of developing social capital, for instance, include receptive and expressive communication, empathy, perspective taking, self-awareness, social cognition/other awareness, and the ability to lead in a facilitative manner. For digital tasks, this is further compounded by the necessity of having perspective, empathy, and social cognition in a remote-located environment where face-to-face contact is not available for social cuing by voice quality, facial expressions, or body postures.

3+3 Six Traits Digital Collaboration Rubric. The rubric, developed from material generated by the qualitative analysis of student work samples through the body of work method, discourse analysis, and cross case analysis, was constrained by the structure of the assessment task implicit in student work, and so may not fully reflect digital collaboration in a different context. To some extent, its conceptualization of collaborative processes and products is construct-dependent on the Arctic Trek Performance Assessment task, and may not adequately fit a different CSCL task.

One limitation noted by raters and review from the field is the subjectivity of the language in the 3+3 Six Traits Digital Collaboration Rubric. One researcher noted that the word "shared" as in "shared content or resources" could be construed by educators to mean sharing a belief, implying that another collaborator could simply accept or reject this belief, which would not lead to co-construction of knowledge. Rather, "share" in this context was used in lieu of "reported content or resources" as a prior review suggested that the word "report" reflected a sense of closed content, seeming less aligned with leading to collaboratively co-constructed new knowledge.

One difficulty in coding and describing traits is deciding how much something matters, or should matter, in performing a CSCL task. For example, many groups engaged on discourse around progress, so this was added to the first version of the rubric. However, the reporting or tracking of progress did not impact scores, and scoring high on the progress trait did not relate directly to an overall high score. While interactive regulated learning traits were present in nearly every sample, and are seemingly intuitive to any sort of collaborative exercise, this trait, greatly more encompassing of behaviors than "reporting progress" still did not relate directly to an overall higher score on the rubric. The distinction made between the dimensions collaborative process and products helps to address this by distinguishing where groups fall in their collaborative development, i.e. groups may be going through the processes that support collaboration, but have not yet mastered the final steps.

Limitations to Internal Validity

As discussed in Chapter III**,** Messick (1995) describes validity as being defined by as how the results of the study are interpreted and used in a social context. The results of this study will be valid due to the fact that the findings of this study are considered preliminary exploration of researched topics in a new setting, offering next steps and direction for future research or potential application to practice.

Ecological sampling increases construct relevance and validity by considering authentic tasks and elements that differentiate between novice and expertise in the task.

Both the Arctic Trek performance task and the 3+3 Digital Collaboration Rubric were bounded by task analysis and ecological sampling, thus supporting internal validity.

Limitations to External Validity

Student ability in collaboration in a digital environment as displayed in the rubric-based assessment of student work samples in this study is not explicitly generalizable to other students, collaborative tasks, or educational settings due to sample size, sampling procedure, and assessment process and content concerns. The patterns and trends seen may be somewhat comparable in other groups or settings, and with other products, but this is not known at this time. The results of this study can act as a guide for thought processes regarding further exploration of the topic.

Implications

Findings from this study suggest that students may lack experience with the concept and practice of collaboration, and the sub-skills necessary to collaborate successfully within a technological framework.

The results of this study point towards a need for comprehensive development in the instructional, professional development, research and leadership areas of K-12 education in order to support the integration of 21st century skills such as collaboration and ICT Literacy in K-12 system.

Implications for action in the field are several. Given the degree of distance between research and practice strands in the field of education, the impetus for change regarding the integration of 21st century skills and the new pedagogical strategies that will best accommodate the incorporation of those skills will likely require direct action in the field of practice. Perhaps exploratory research such as this study can provide direction for action, and action can be evaluated and refined to produce ever-optimized results for teaching and learning, with the end goal of student achievement for optimal participation in and contribution to society in a life-long capacity.

Implications for Instructional Design

A comprehensive instructional design model will need to highlight overarching constructs and instructional goals; encompass the domains that support development of the overarching constructs; include a focus on skills and sub-skills pertinent to fluency or mastery in those domains; consider developmental implications as well as vertical alignment within domain and horizontal alignment between domains; plan for a variety of instructional modalities and practice applications; generate supports and accommodations to maximize learning; and map assessment options.

Clarifying constructs and instructional goals will be important. Clearly defined constructs and instructional goals will facilitate the instructional design process, direct intentions, and allow for specificity in backwards planning. Educators will need to specify domains and align sub-skills. Diagnostic analysis of overarching constructs and explicit instructional goals allow for greater clarity in outlining essential sub-skills and working towards alignment across developmental levels and between domains, such that skills are introduced when students are ready to learn them and when the skills can be supported and enhanced by similarly located skills in related domains.

In order to more thoroughly and successfully teach a greater number of students with respect to individual receptive variation, it is necessary to have a wealth of ideas for practicing application of emerging and newly acquired skills in order to have multiple and varied opportunities to work towards mastery. These practice applications should reflect a diversity of instructional modalities so that individual learning styles and preferences are met. This requires the review and acquisition of resources that are both conceptual and practical.

Supports and accommodations will need to be in place such that instruction and the level of support for learning is congruent with the needs of individuals and groups of learners in order to achieve an instructional climate where most of the time learners are operational at their appropriate rate and level of skills development.

Assessments, which will be key to the process, are built into the initial instructional design phase to organize the backwards-planning process with the end measure in mind. Knowing how the instructional goals will be assessed allows for alignment of efforts throughout the instructional design process. Assessment for 21st century skills such as digital collaboration can be performance-based and can be tied to practice applications using a classroom-based performance assessment approach that provides continuous feedback and opportunities for growth throughout the instructional program.

Implications for Professional Development

Educators who are competent, confident, and able to seamlessly integrate a variety of skill sets through curricular content are key to solid educational planning and practices, and translate to better instructional support for students. The findings of this study highlight potential need for professional development in the areas of technology and collaboration, as well as the domains and sub-skills that support collaboration. Results indicate that educators may not be well prepared to teach to digital collaboration, and may lack the requisite training in the domains and sub-skills that contribute to the development of collaborative skill in order to feel confident providing instruction. Moreover, findings imply that educators themselves may lack experience collaborating in digital environments, further complicating their ability to integrate such skills into the classroom.

Districts and region-level leadership units can use a needs assessment to determine the types of training experiences and levels of training to offer educators in order to prepare them to model and instruct in technology-based collaboration and other 21st century skills. Training in instructional design and curriculum development can assist educators in creating ways to integrate 21st century skills with content areas, thus changing the pedagogical ground of the standard didactic instructional methods.

Figure 23 outlines both the content and the format for teacher training in skills development for a diagram of needs-based collaborative learning in a digital environment, based on Cognitive Task Analysis of the enabling skills in technology and collaboration; the feedback from educators in the field; Backward Design principles; and the literature for best practices in professional development.

Curriculum Development for Teaching Digital Collaboration

As a relatively undefined curricular area, teachers may not have a clear idea of the utility of collaboration in a digital environment, how to teach to it, or how to measure student achievement in this area. Once a desired outcome has been established with a way to measure success, teachers can work backwards to plan learning opportunities with scaffolds to enhance success, using the Backward Design strategy for curriculum development and instructional design described by Wiggins and McTighe (2001).

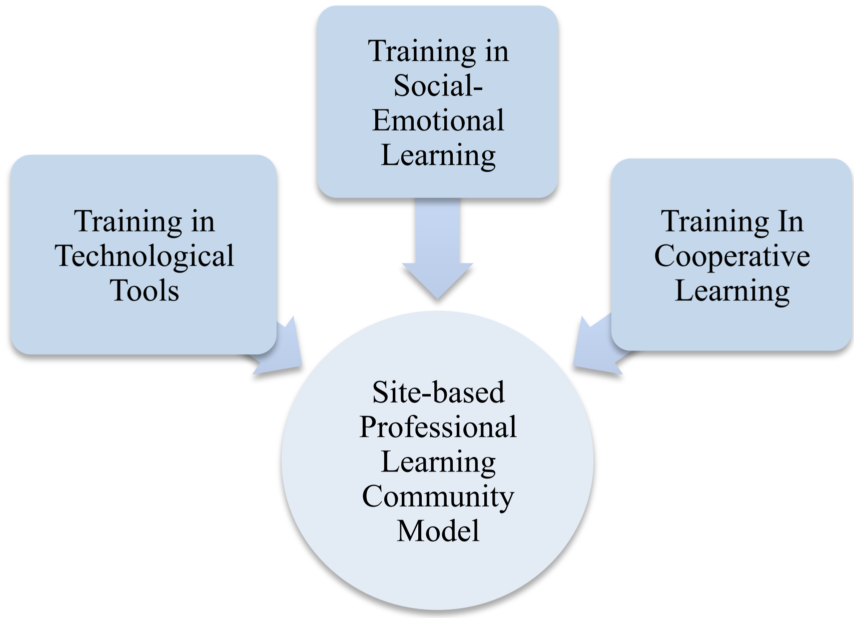
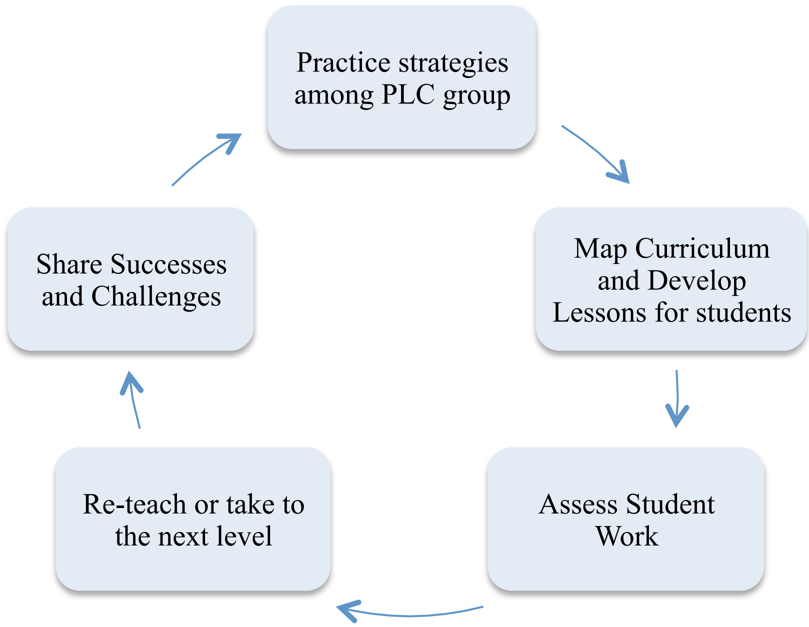


Figure 23. Collaboration in a Digital Environment professional development model with content and format.

Several curricular frameworks exist for 21^{st} century skills, but few are integrated into instructional programs in the classroom. Consequently, teachers wishing to teach 21^{st} century skills must find a way to integrate these skills into existing curriculum, or create a 21^{st} century skills curriculum, including the use of collaborative learning in a digital environment, that can be folded into core content areas, such as science, social studies or literature.

The use of Professional Learning Communities and a site-based approach to 21^{st} century skills could enhance efforts by having a school-wide focus on aligned SEL, NETS, and Cooperative Learning skills within a supportive atmosphere of continuous improvement. See Figure 24 for a possible Professional Development model created in response to reported teacher needs and student work sample Notebooks.



Please Note: *Assessment of student work is a two-way dual assessment: Assessed by process and by product; assessed by teacher and by group.*

Figure 24. Digital Collaboration Professional Development Process

Lesson planning, refinement and alignment. The use of Professional Learning Communities to work as site or district-based teams for the development of 21st century skills curriculum in technology and collaboration could lend itself to continuous and reflective planning regarding lessons, assessments and outcomes for student growth in this area which is aligned with research-based recommendations as discussed in Chapter I. As teachers examine student progress, observed student needs for skill development will drive planning efforts and alignment between skills and grade levels in the sub-domain areas of cooperative learning, technology, and social-emotional learning. As student needs become clear, educators can focus their professional development efforts on the domain areas as well as the development of their 21st century skills curriculum with collaboration in a digital environment.

Conclusion

This exploratory study addresses the relatively new research area of skill development in collaboration in a digital environment. Drawing on a sample of 11-, 13- and 15-year-olds, the study is intended to highlight the interaction of the research with direct systemic implications for application in practice. As such, this study attempts to anticipate and attend to the various needs of students and practitioners in the field in order to facilitate the integration and instruction of digital collaboration and requisite supportive skills within the K-12 educational setting.

The future of K-12 education can be positively influenced by the inclusion of 21st century skills. Viewed broadly as a set of guidelines for complex thinking and application of abilities, these skills can enrich instruction to help students create deeper meaning at all levels of learning and become ever more proficient in their capacity for meaningful participation in a global society.

APPENDIX A

BLUEPRINT CONSTRUCT CHECKLISTS

Consumer in Social Networks

(ATC21S, 2010)

These snippets show constructs and example loadings of a few item scores in the scenario.

	CONSUMER IN SOCIAL NETWORKS	**1**	**0**	**1**
	Discriminating consumer	0	0	0
High	Judging credibility of sources/people			
	Integrating information in coherent knowledge framework			
	Searches suited to personal circumstances			
	Filter, evaluate, manage, organize and reorganize information/people			
	Seeking expert knowledge (people through networks)			
	Select optimal tools for tasks/topics			
	Conscious consumer	1	0	0
Middle	Select appropriate tools and strategies (strategic competence)			
	Construct targeted searches			
	Compiling information systematically	x access correct interface and retrieve secret code OneNote		
	Knowing that credibility is an issue (web pages, people, networks)			
	Emerging consumer	0	0	1
Low	Performing basic tasks			x click identified link
	No concept of credibility			
	Search for pieces of information using common search engines (e.g. movie guides			
	Knowing that tools exist for networking (e.g. Facebook)			

Producer in Social Networks

(ATC21S, 2010)

	PRODUCER IN SOCIAL NETWORKS	**0**	**0**	**0**
	Creative producer	0	0	0
High	Team situational awareness in process			
	Optimize assembly of distributed contribution to products			
	Extending advanced models (e.g. business models)			
	Producing attractive digital products using multiple technologies / tools			
	Choosing among technological options for producing digital products			
	Functional producer	0	0	0
Middle	Establishing and managing networks & communities			
	Awareness of planning for building attractive websites, blogs, games			
	Organizing communication within social networks			
	Developing models based on established knowledge			
	Developing creative, expressive and/or useful content artifacts and tools			
	Awareness of security & safety issues (ethical and legal aspects)			
	Using networking tools and styles for communication among people			
	Emerging producer	0	0	0
Low	Produce simple representations from templates			
	Start an identity			
	Use a computer interface			
	Post an artifact/ Perform basic production tasks			

Developer of Social Capital

(ATC21S, 2010)

	DEVELOPER OF SOCIAL CAPITAL	0	0	0
	Visionary connector	0	0	0
High+	Take a cohesive leadership role in building a social enterprise			
	Reflect on experience in social capital development (should span categories below)			
	Proficient connector	0	0	0
High	Initiate opportunities for developing social capital through networks (e.g. support for development)			
	Encourage multiple perspectives and support diversity in networks (social brokerage skills)			
	Functional connector	0	0	0
Middle	Encourage participation in and commitment to a social enterprise			
	Awareness of multiple perspectives in social networks			
	Contribute to building social capital through a network			
	Emerging connector	0	0	0
Low	Participating in a social enterprise			
	Observer or passive member of a social enterprise			
	Knowing about social networks			

Participator in Intellectual Capital (Collective Intelligence)

(ATC21S, 2010)

PARTICIPATOR IN INTELLECTUAL CAPITAL (COLLECTIVE INTELLIGENCE)		**0**	**0**	**0**
	Visionary builder	0	0	0
Hi+	Questioning existing architecture of social media and developing new architectures			
	Functioning at the interfaces of architectures to embrace dialogue			
	Proficient builder	0	0	0
Hi	Understanding and using architecture of social media such as tagging, polling, role-playing and modeling spaces to link to knowledge (deleted "of experts") in an area			
	Identifying signal versus noise in information			
	Interrogating data for meaning			
	Making optimal choice of tools to access collective intelligence			
	Sharing and reframing mental models (plasticity)			
	Functional builder	0	0	0
Mid	Acknowledges multiple perspectives			
	Thoughtful organization of tags, graphic organizers and other representations and displays			
	Understanding mechanics of collecting and assembling data			
	Knowing when to draw on collective intelligence			
	Sharing representations			
	Emerging Builder	0	0	0
Low	Knowledge of survey tools			
	Able to make tags			
	Posting a question			
			PU	

APPENDIX B

SUMMARY TABLE OF ATC21S SCENARIO BLUEPRINT DATA COLLECTION

Assessment Blueprint ATC21S Demonstration Tasks: ICT Literacy

(ATC21S, 2010)

Levels (Progressive)	**ICT Literacy—Learning in digital communities** CONSTRUCT/Learning Outcomes				Total
	Consumer	Producer	Social Capital	Intellectual Capital	
Level 4	N/A	N/A	Web 0 Arctic 1 2LChat 0	Web 0 Arctic 0 2Lchat 0	Web: 0 Arctic: 1 2Lchat: 0
Level 3	Web 0 Arctic 2 2Lchat 0	Web 0 Arctic 2 2Lchat 0	Web 0 Arctic 6 2Lchat 1	Web 10 Arctic 2 2Lchat 1	Web: 10 Arctic: 12 2Lchat: 2
Level 2	Web 8 Arctic 6 2Lchat 0	Web 4 Arctic 16 2Lchat 8	Web 7 Arctic 0 2Lchat 6	Web 6 Arctic 7 2Lchat 0	Web: 25 Arctic: 29 2Lchat: 14
Level 1	Web 2 Arctic 2 2Lchat 2	Web 4 Arctic 0 2Lchat 6	Web 1 Arctic 0 2Lchat 6	Web 2 Arctic 2 2Lchat 0	Web: 9 Arctic: 4 2Lchat: 14
Total	Web: 10 Arctic: 10 2Lchat: 2	Web: 8 Arctic: 18 2Lchat: 14	Web: 8 Arctic: 7 2Lchat: 13	Web: 18 Arctic: 11 2Lchat: 1	**120 per age group plus PU/FP/HUE, Practice, & Covariates**

*Some CR items (Constructed Response) will measure *up through* the listed level (listed level is top score).

APPENDIX C

KSAVE MODELS

Ways of Working: Communication

(Binkley et al., 2012)

Table 5: Ways of working - communication

Knowledge	Skills	Attitudes/Values/Ethics
Competency in language in mother tongue. • *Sound knowledge of basic vocabulary, functional grammar and style, functions of language.* • *Awareness of various types of verbal interaction (conversations, interviews, debates, etc.) and the main features of different styles and registers in spoken language.* • *Understanding the main features of written language (formal, informal, scientific, journalistic, colloquial, etc.).* Competency in additional language/s. • *Sound knowledge of basic vocabulary, functional grammar and style, functions of language.* • *Understanding the paralinguistic features of communication (voice-quality features, facial expressions, postural and gesture systems).* • *Awareness of societal conventions and cultural aspects and the variability of language in different geographical, social and communication environments.*	Competency in language in mother tongue and additional language/s. • *Ability to communicate, in written or oral form, and understand, or make others understand, various messages in a variety of situations and for different purposes.* • *Communication includes the ability to listen to and understand various spoken messages in a variety of communicative situations and to speak concisely and clearly.* • *Ability to read and understand different texts, adopting strategies appropriate to various reading purposes (reading for information, for study or for pleasure) and to various text types.* • *Ability to write different types of texts for various purposes. To monitor the writing process (from drafting to proof-reading).* • *Ability to formulate one's arguments, in speaking or writing, in a convincing manner and take full account of other viewpoints, whether expressed in written or oral form.* • *Skills needed to use aids (such as notes, schemes, maps) to produce, present or understand complex texts in written or oral form (speeches, conversations, instructions, interviews, debates).*	Competency in language in mother tongue. • *Development of a positive attitude to the mother tongue, recognizing it as a potential source of personal and cultural enrichment.* • *Disposition to approach the opinions and arguments of others with an open mind and engage in constructive and critical dialogue.* • *Confidence when speaking in public.* • *Willingness to strive for aesthetic quality in expression beyond the technical correctness of a word/phrase.* • *Development of a love of literature.* • *Development of a positive attitude to intercultural communication.* Competency in additional language/s. *Sensitivity to cultural differences and resistance to stereotyping.*

Ways of Working: Collaboration and Teamwork

(Binkley et al., 2012)

Table 6: Ways of working - collaboration, teamwork

Knowledge	Skills	Attitudes/Values/Ethics
Interact effectively with others • *Know when it is appropriate to listen and when to speak* Work effectively in diverse teams • *Know and recognize the individual roles of a successful team and know own strengths and weaknesses recognizing and accepting them in others* Manage projects • *Know how to plan, set and meet goals and to monitor and re-plan in the light of unforeseen developments*	Interact effectively with others • *Speak with clarity and awareness of audience and purpose. Listen with care, patience and honesty* • *Conduct themselves in a respectable, professional manner* Work effectively in diverse teams • *Leverage social and cultural differences to create new ideas and increase both innovation and quality of work* Manage projects • *Prioritize, plan and manage work to achieve the intended group result* Guide and lead others • *Use interpersonal and problem-solving skills to influence and guide others toward a goal* • *Leverage strengths of others to accomplish a common goal* • *Inspire others to reach their very best via example and selflessness* • *Demonstrate integrity and ethical behavior in using influence and power*	Interact effectively with others • *Know when it is appropriate to listen and when to speak* • *Conduct themselves in a respectable, professional manner* Work effectively in diverse teams • *Show respect for cultural differences and be prepared to work effectively with people from a range of social and cultural backgrounds* • *Respond open-mindedly to different ideas and values* Manage projects • *Persevere to achieve goals, even in the face of obstacles and competing pressures* Be responsible to others • *Act responsibly with the interests of the larger community in mind*

Tools for Working: Information Literacy

(Binkley et al., 2012)

Table 7: Tools for working - information literacy

Knowledge	Skills	Attitudes/Values/Ethics
Access and evaluate information • *Access information efficiently (time) and effectively (sources)* • *Evaluate information critically and competently* Use and manage information • *Use information accurately and creatively for the issue or problem at hand* • *Manage the flow of information from a wide variety of sources* • *Apply a fundamental understanding of the ethical/legal issues surrounding the access and use of information* • *Basic understanding of the reliability and validity of the information available (accessibility/acceptability) and awareness of the need to respect ethical principles in the interactive use of IST.* Apply technology effectively • *Use technology as a tool to research, organize, evaluate and communicate information* • *Use digital technologies (computers, PDAs, media players, GPS, etc.), communication/networking tools and social networks appropriately to access, manage, integrate, evaluate and create information to successfully function in a knowledge economy.*	Access and evaluate information • *Ability to search, collect and process (create, organize, distinguish relevant from irrelevant, subjective from objective, real from virtual) electronic information, data and concepts and to use them in a systematic way;* Use and manage information • *Ability to use appropriate aids presentations, graphs, charts, maps) to produce, present or understand complex information;* • *Ability to access and search a range of information media including the printed word, video and websites and to use internet-based services such as discussion fora and e-mail;* • *Ability to use information to support critical thinking, creativity and innovation in different contexts at home, leisure and work.* • *Ability to search, collect and process written information, data and concepts in order to use them in study and to organize knowledge in a systematic way. Ability to distinguish, in listening, speaking, reading and writing, relevant from irrelevant information.*	Access and evaluate information • *Propensity to use information to work autonomously and in teams; critical and reflective attitude in the assessment of available information.* Use and manage information • *Positive attitude and sensitivity to safe and responsible use of the Internet, including privacy issues and cultural differences.* • *Interest in using information to broaden horizons by taking part in communities and networks for cultural, social and professional purposes.*

Tools for Working: Information Communication Technology Literacy

(Binkley et al., 2012)

Table 8: Tools for working - ICT literacy

Knowledge	Skills	Attitudes/Values/Ethics
Access and evaluate information & communication technology • *Understanding of the main computer applications, including word processing,* • *spreadsheets, databases, information storage and management;* • *Awareness of the opportunities given by the use of Internet and communication via electronic media (e-mail, videoconferencing, other network tools); and the differences between the real and virtual world* Analyze media • *Understand both how and why media messages are constructed, and for what purposes* • *Examine how individuals interpret messages differently, how values and points of view are included or excluded, and how media can influence beliefs and behaviors* • *Understand the ethical/legal issues surrounding the access and use of media* Create media products • *Understand and know how to utilize the most appropriate media creation tools, characteristics and conventions* • *Understand and know how to effectively utilize the most appropriate expressions and interpretations in diverse, multi-cultural environments*	Access and evaluate information & communication technology • *Access ICT efficiently (time) and effectively (sources)* • *Evaluate information and ICT tools critically and competently* Use and manage information • *Use ICT accurately and creatively for the issue or problem at hand* • *Manage the flow of information from a wide variety of sources* • *Apply a fundamental understanding of the ethical/legal issues surrounding the access and use of ICT and media* • *Employ knowledge and skills in the application of ICT and media to communicate, interrogate, present and model* Create media products • *Utilize the most appropriate media creation tools, characteristics and conventions , expressions and interpretations in diverse, multi-cultural environments* Apply technology effectively • *Use technology as a tool to research, organize, evaluate and communicate information* • *Use digital technologies (computers, PDAs, media players, GPS, etc.), communication/networking tools and social networks appropriately to access, manage, integrate, evaluate and create information to successfully function in a knowledge economy* • *Apply a fundamental understanding of the ethical/legal issues surrounding the access and use of information technologies.*	Access and evaluate information & communication technology • *Be open to new ideas, information, tools and ways of working but evaluate information critically and competently* Use and manage information • *Use information accurately and creatively for the issue or problem at hand respecting confidentiality, privacy and intellectual rights* • *Manage the flow of information from a wide variety of sources with sensitivity and openness to cultural and social differences* • *Examine how individuals interpret messages differently, how values and points of view are included or excluded, and how media can influence beliefs and behaviors* Apply and employ technology with honesty & integrity • *Use technology as a tool to research, organize, evaluate and communicate information accurately and honestly with respect for sources and audience* • *Apply a fundamental understanding of the ethical/legal issues surrounding the access and use of information technologies*

APPENDIX D

SIX TRAITS DIGITAL COLLABORATION CHECKLIST

Six Trait Digital Collaboration Checklist

Trait	Not Present	Number of Incidents			
	0	1-3	4-6	7-9	>9
Seek Help or Give Support					
Direct Process (someone directs)					
Clarify Process (someone clarifies)					
Time Management (awareness of time constraints, conserving efforts)					
Goal Setting (deciding on a task or benchmark to achieve)					
Develop Threads of Discourse (that may or may not be task related)					
Visual Organization of document (numbers, chunks, colors, outline form, underlines, etc)					
Social Discourse (hi, please, thanks, lol, O.o; ><, @__@, or other social text speak)					
# of Entries					
# of Questions					
Role Conflict or Confusion					
Task Conflict or Confusion					
Affective statements (including about how difficult task is)					
Off-task Behaviors or Topics (anything not related to working with group, content or process)					
Comments:					

APPENDIX E

SIX TRAITS DIGITAL COLLABORATION RUBRIC

Six Trait Digital Collaboration Rubric				
Group:		**Rater:**		
Trait	**Non-collaborative** (0)	**Emerging** (1)	**Developing** (2)	**Capable** (3)
Identification & Role Assignment *(Who are the participants and what are their roles?)*	No id of participants or discussion of roles	Id or roles mentioned or queried; may be role conflict	Some participants id or chose roles; or role conflict	All participants id and all roles are assigned
Task Assignment *(Who is responsible for what tasks?)*	No discussion of task assignment	Task assignment mentioned or queried; or task conflict	Some tasks are assigned; may be task conflict	All tasks assigned; no task conflict
Report/Share Content *(Have answers or responses to tasks been posted?)*	No content is reported or shared	Some content is mentioned or discussed; rationale not given	Some content is shared; some rationale given	Most content is shared; with some rationale; may not reflect all participants
Report/Share or Check Progress *(How is everyone progressing? Is anyone stuck or needing help?)*	No mention of progress in task	Progress status mentioned, but no explanation or help seeking	Progress status mentioned and explained; and/or check progress of others; and/or help sought or offered	Participants skilled and task complete without needing check-in
Collaboration *(Did participants add to, evaluate or offer an alternative response to the shared content?)*	No shared content or shared but not acknowledged	Shared content acknowledged; no evaluative or alternative comments offered	Some shared content is acknowledged, corrected, added to or evaluated	Each piece of shared content is acknowledged, corrected, added to or evaluated
Co-Construction of Knowledge *(Did participants use shared and evaluated content to construct final answers or responses or complete a task?)*	No content shared or shared but no response or has response but no evaluation	Agreement with or alternative response to evaluated shared content is mentioned, requested or discussed but not resolved	Agreement on one or more answers or responses through evaluated, corrected or enhanced content	Agreement on each answer or response through evaluated, corrected or enhanced content
Total Score:				
Comments:				

APPENDIX F

3+3 SIX TRAITS DIGITAL COLLABORATION RUBRIC

3+3 Six Trait Digital Collaboration Rubric						
Group:			**Rater:**			
Dimension	**Trait**	**Non-collaborative (0)**	**Emerging (1)**	**Developing (2)**	**Capable (3)**	**Trait Score** __/3
Collaborative Learning Processes	**Identification & Role Assignment** *(Who are the participants and what are their roles?)*	No id of participants or discussion of roles	Id or roles mentioned or queried; may have role conflict	Some participants id or take roles; or role conflict	All participants id and all roles are assigned; any role conflict is resolved	
	Task Assignment *(Who is responsible for what tasks?)*	No discussion of task assignment	Task assignment mentioned or queried; may have task conflict	Some tasks are assigned; may have task conflict	All tasks assigned; no task conflict	
	Interactive Regulated Learning *(Is there evidence of seeking or offering help; reporting progress; clarifying process; self or group evaluation; time management; task orientation; goal setting; mediation; or appreciation?)*	No evidence of seeking or offering help; reporting progress; clarifying process; self or group evaluation; time management; task orientation; goal setting; mediation; or appreciation	Evidence of *any* Interactive Regulated Learning behaviors as described in column 1, but participants do not acknowledge or respond	Interactive Regulated Learning behaviors are acknowledged or responded to, but response does not resolve the need or issue raised	Interactive Regulated Learning behaviors elicit acknowledgement or response through the resolution of the need or issue, if necessary	
					Total score on Collaborative Learning Processes Dimension	__/9
Collaborative Learning Products	**Shared Content** *(Have answers or responses to tasks been posted?)*	No content is shared	Some content is mentioned or discussed; rationale not given	Some content is shared; some rationale given	Most content is shared; with some rationale; may not reflect all participants	
	Collaboration *(Did participants add to, evaluate or offer an alternative response to the shared content?)*	No shared content or content shared but not acknowledged; requested but not submitted	Some shared content acknowledged; no evaluative or alternative comments offered	Some shared content is acknowledged, corrected, added to or evaluated	Each piece of shared content is acknowledged, corrected, added to or evaluated	
	Co-Construction of Knowledge *(Did participants use shared and evaluated content to construct final answers or responses or complete a task?)*	No content shared or content shared but no response or has response but no evaluation	Agreement with or alternative response to evaluated shared content is mentioned, requested or discussed but not resolved	Agreement on one or more answers or responses through evaluated, corrected or enhanced content	Agreement on each answer or response through evaluated, corrected or enhanced content	
					Total score on Collaborative Learning Products Dimension	__/9

APPENDIX G

ASYNCHRONOUS INTER-RATER DIRECTIONS

Thank you for so much for helping me out!

You are serving as a "purposively sampled inter-rater" meaning that we needed teachers from different levels of education to rate the same student samples using the rubric, to see how much variance there is in the scores. If the rubric is reliable, it will perform consistently across raters and provide the same or near-same score for each sample no matter who (within the profession) uses the tool.

There are actually 8 student work samples (I realize I said 7), labeled “Notebook #”

There are eleven Attachments to the email:

1) This orientation/set of instructions

2) Notebooks 1, 2, 6, 8, 14, 22, 30 and 33.

3) The 3 + 3 Six Trait Digital Collaboration Rubric.

4) A Scoring sheet that is just a word doc so you can add to it and send it back to me. I created a format for reporting your scores.

Rubric:

The rubric has two dimensions: collaborative learning processes and collaborative learning products. Therefore, each group will get a score per each trait, and then a “total score” for each dimension.

The Rubric could be used in a formative manner to guide instruction, as well as in a summative manner to assess learning and progress in this skill area.

To assess the student work samples using the rubric, please follow this procedure:

1. Read thru the student work sample. You may make notations on the sample to highlight or code information if you desire.
2. You may want to read through the sample again for clarity.
3. Read through the traits on the Rubric.
4. With the work sample and rubric side by side, match the evidence from student work to the elements in the descriptors on the rubric.
5. Refer to both the descriptors and student work sample as much as you need to in order to make a thorough evaluation of the work.
6. Circle the appropriate descriptor box for each trait.
7. Add the scores per trait, as outlined per descriptor box, into the score column.
8. Send me your results by Sunday evening, February 19th.

Please note these aspects about the student work:

Spelling, grammar, and writing conventions were not specified as integral to the task and should not be considered in evaluating this work.

Also, the students were of different ages (11, 13, and 15) and are from different countries (US, Australia and Singapore). The data is de-identified, so we do not know which students belong to which documents, and the sample size will be too small to analyze on a country level.

Assessment Background:

Students were given a 45-minute computer-based performance assessment called Arctic Trek in a team format. Teams of 3-4 students did an interactive web search/web quest type exercise to demonstrate their ability with technology and collaboration, among other skills. The team members were co-located on separate computers and were instructed not to talk to one another if they were near enough to each other in the classroom. They were not told beforehand who was on their team, and each team member was assigned a number (ex: 144). Their only means of communication to collaboratively solve the clues and enter their information was through the Notebook, which is a Google doc.

Students had to find the link to the shared document/Notebook, and enter it to share the information they found, get help, or other such behaviors. The main administration instructions for teachers are copied below. Teachers were to be very hands-off as with most assessments, and not give help even if the students had difficulty accessing the doc or links or the computer.

These samples are from cognitive lab and pilot data, so there was some variance across classrooms as the instrument was adjusted slightly.

Students were told in the Trek to find the answers to questions by searching the clues, and to access their team members on the Notebook, choose roles, and share answers.

Test Administration instructions (For teachers administering Arctic Trek)

In about 5 MINUTES, give students "ASK THREE THEN ME" directions. Every student is expected to explore three sources of information before asking instructor or test administrator help. These three are: (1) task directions and resources on each screen, (2) questions online of team members to get and give help, and (3) access internet for information PRIOR to requesting help. Instructor help is to be RARELY given (see below for instructions on how), and students are to explore and do their best with the information and team members available. Instruct students that collaborating and using the Internet is expected and is NOT cheating for this assessment.

SAY:

"I will provide you with ASK THREE THEN ME directions. Every student is expected to use three sources of information before asking for help. First, you are expected to use task directions and resources on each screen. Second, work with your team members to get and give help. Third, use the internet for information. PLEASE KEEP IN MIND THAT THIS IS NOT CHEATING. Otherwise, you should explore the tasks and do the best you can with the information and team members provided. You are being assessed on YOUR ABILITY to work with tools and people online."

Again, **thank you so very much**, and please don't hesitate to email me with any questions you may have.

Barbara

APPENDIX H

SAMPLE STUDENT NOTEBOOK: HIGH SCORING

Australia Cog Labs: Team One Wave Notebook

Team 1: Type or paste information here for your whole team to see.
Use the menus above to format your text or highlight it with notes. To add pictures or to insert web addresses to other sites, use the Insert menu. Feel free to experiment with this tool! You can always delete parts and start over. first q is challenging
i can i be the decoder ? there are two colors used in the table . page 15 is very hard !!!!!!!!!!!!!!!!!!!!!!!!!!!
Your team's SECRET CODE: XF9
i don't know. i think may should be captin do you guys agree it's jas do you want to be a scout i will jas hmmm aggggggg! ok lets work this out lets vote!me me capinok i think may should be ca
year i know
how do you want to work it out whos going to be captin
yes
WHAT CAN I DO
Jonathan should be scout
who should should be the decoder
i will ally
i havent got a job
w
who is going to be the captain what does everybody want to be who is the captain may 2
because thereare two colours on the table
i will be capten
than i will be capten
than you be scout jono
i havent herd from may do you know what she is doing
i want to be capten
how is derecter i think there is three different colours
i went on a bear populion web sit and i cunted all the diffrent coluers
5

APPENDIX I

SAMPLE STUDENT NOTEBOOK: LOW SCORING

Team 32: Type or paste information here for your whole team to see. Use the menus above to format your text or highlight it with notes. To add pictures or to insert web addresses to other sites, use the Insert menu. Feel free to experiment with this tool! You can always delete parts and start over.

Your team's SECRET CODE: DF5

i

The Work:

Clue 4: interpret results
Clue5: Ice Cave
Clue 3: coloring task
Clue 2: Dinner
Role: Recorder
Role Captain
Role: Scout
Role: Decoder
Clue 1: map

Your team's SECRET CODE: FE4

My answer-- For the clue threeThere had been shown whether they are going to have the high chances to decline or low chances to decline and whether they are declining now or not. Also it shows how they are also being reduced from declining.

Who else is on this team???
5 colors used to describe polar bear population
HOw many colors do u see team?

APPENDIX J

ISTE STANDARDS FOR TECHNOLOGY INSTRUCTION

(ISTE, 2008)

iste nets·t
ADVANCING DIGITAL AGE TEACHING

Effective teachers model and apply the NETS·S as they design, implement, and assess learning experiences to engage students and improve learning; enrich professional practice; and provide positive models for students, colleagues, and the community. All teachers should meet the following standards and performance indicators.

1. 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.

a. Promote, support, and model creative and innovative thinking and inventiveness
b. Engage students in exploring real-world issues and solving authentic problems using digital tools and resources
c. Promote student reflection using collaborative tools to reveal and clarify students' conceptual understanding and thinking, planning, and creative processes
d. Model collaborative knowledge construction by engaging in learning with students, colleagues, and others in face-to-face and virtual environments

2. Design and Develop Digital Age Learning Experiences and Assessments

Teachers design, develop, and evaluate authentic learning experiences and assessment incorporating contemporary tools and resources to maximize content learning in context and to develop the knowledge, skills, and attitudes identified in the NETS·S.

a. Design or adapt relevant learning experiences that incorporate digital tools and resources to promote student learning and creativity
b. Develop technology-enriched learning environments that enable all students to pursue their individual curiosities and become active participants in setting their own educational goals, managing their own learning, and assessing their own progress
c. Customize and personalize learning activities to address students' diverse learning styles, working strategies, and abilities using digital tools and resources
d. Provide students with multiple and varied formative and summative assessments aligned with content and technology standards and use resulting data to inform learning and teaching

3. Model Digital Age Work and Learning

Teachers exhibit knowledge, skills, and work processes representative of an innovative professional in a global and digital society.

a. Demonstrate fluency in technology systems and the transfer of current knowledge to new technologies and situations
b. Collaborate with students, peers, parents, and community members using digital tools and resources to support student success and innovation
c. Communicate relevant information and ideas effectively to students, parents, and peers using a variety of digital age media and formats
d. Model and facilitate effective use of current and emerging digital tools to locate, analyze, evaluate, and use information resources to support research and learning

(ISTE, 2008)

4. 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.

a. Advocate, model, and teach safe, legal, and ethical use of digital information and technology, including respect for copyright, intellectual property, and the appropriate documentation of sources

b. Address the diverse needs of all learners by using learner-centered strategies providing equitable access to appropriate digital tools and resources

c. Promote and model digital etiquette and responsible social interactions related to the use of technology and information

d. Develop and model cultural understanding and global awareness by engaging with colleagues and students of other cultures using digital age communication and collaboration tools

5. Engage in Professional Growth and Leadership

Teachers continuously improve 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.

a. Participate in local and global learning communities to explore creative applications of technology to improve student learning

b. Exhibit leadership by demonstrating a vision of technology infusion, participating in shared decision making and community building, and developing the leadership and technology skills of others

c. Evaluate and reflect on current research and professional practice on a regular basis to make effective use of existing and emerging digital tools and resources in support of student learning

d. Contribute to the effectiveness, vitality, and self-renewal of the teaching profession and of their school and community

iste.org/nets

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APPENDIX K

ISTE ESSENTIAL CONDITIONS FOR TECHNOLOGY IN EDUCATION

(ISTE, 2008)

iste nets
ESSENTIAL CONDITIONS

Essential Conditions

Necessary conditions to effectively leverage technology for learning:

Shared Vision
Proactive leadership in developing a shared vision for educational technology among all education stakeholders, including teachers and support staff, school and district administrators, teacher educators, students, parents, and the community

Empowered Leaders
Stakeholders at every level empowered to be leaders in effecting change

Implementation Planning
A systemic plan aligned with a shared vision for school effectiveness and student learning through the infusion of information and communication technology (ICT) and digital learning resources

Consistent and Adequate Funding
Ongoing funding to support technology infrastructure, personnel, digital resources, and staff development

Equitable Access
Robust and reliable access to current and emerging technologies and digital resources, with connectivity for all students, teachers, staff, and school leaders

Skilled Personnel
Educators, support staff, and other leaders skilled in the selection and effective use of appropriate ICT resources

Ongoing Professional Learning
Technology-related professional learning plans and opportunities with dedicated time to practice and share ideas

Technical Support
Consistent and reliable assistance for maintaining, renewing, and using ICT and digital learning resources

Curriculum Framework
Content standards and related digital curriculum resources that are aligned with and support digital age learning and work

Student-Centered Learning
Planning, teaching, and assessment centered around the needs and abilities of students

Assessment and Evaluation
Continuous assessment of teaching, learning, and leadership, and evaluation of the use of ICT and digital resources

Engaged Communities
Partnerships and collaboration within communities to support and fund the use of ICT and digital learning resources

Support Policies
Policies, financial plans, accountability measures, and incentive structures to support the use of ICT and other digital resources for learning and in district school operations

Supportive External Context
Policies and initiatives at the national, regional, and local levels to support schools and teacher preparation programs in the effective implementation of technology for achieving curriculum and learning technology (ICT) standards

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APPENDIX L

TEST ADMINISTRATOR MANUAL FOR ARCTIC TREK ASSESSMENT

Berkeley Evaluation and Assessment Research Center
University of California, Berkeley

ATC21S
ASSESSMENT & TEACHING OF 21st CENTURY SKILLS

PILOT TESTING

Test Administrator Manual

Checklist for Test Proctors

Note: This checklist is provided as a summary only. It is essential that you read this entire guide in order to ensure the proper administration of the test.

- **Before the testing**
- ✓ Read the Test Administrator Manual in its entirety.
- ✓ Print this manual if you are reading electronic copy of the manual and think you might need a paper copy during the administration of the test.
- ✓ Communicate with the Test Coordinator (Project Administrator) of your country to review the testing schedule and to arrange for the students who require accommodations. Also review procedures in the Test Administrator Manual.
- ✓ Check if technology requirements are met on your student computers (see *Technical Requirements* section).
- ✓ Receive your student logins and passwords, and online access to instructor preview scenarios (contact Test Coordinator for student logins and passwords).
- ✓ Access online preview scenarios to become familiar with them.
- ✓ Decide if Kodu to be installed or not (optional but engaging for students).
- ✓ Ensure that students are provided with the necessary student ID and passwords. If you are planning to distribute login and password forms, make sure that you have forms available printed in advance.
- ✓ Have a timer available.
- ✓ Ensure administrator knows how to correctly answer all parts of the scenario.
- ✓ Ensure administrator has access to a computer workstation for every student.
- ✓ Ensure computers meet requirements and have access to Internet, tasks and links (see *Technical Requirements* section).

- **During the testing**
- ✓ Post a "Testing—Please Do Not Disturb" sign on the room where testing is conducted.

- ✓ Ensure all students have comfortable and adequate workspaces, and that students on same team should be seated at least two to three workstations apart, to effectively encourage interactions to be online.
- ✓ Monitor students to ensure they are working in the correct sections of the test.
- ✓ Monitor students' handling of computer hardware to keep it in proper condition.
- ✓ If you are administering accommodations, make sure that the accommodations are provided as were determined prior to testing and according to the regulations of the region in which the test is being administered.
- ✓ Take notes during the test of any testing irregularities and notify the test coordinator of your country after the testing. Be as specific as possible. If you notice any technical issues or issues with the computer testing system, please record the issue in the Teach Aid text box for the computer on which the problem was found.

❖ **After the testing**

- ✓ Verify that all login and password forms have been collected.
- ✓ Verify that all computer hardware used by students during testing is left in proper condition.
- ✓ Verify that any testing irregularities are reported to the testing coordinator.

Guidelines for a Suitable Testing Environment

- The testing room should be appropriately heated or cooled, adequately ventilated, and free from distractions.
- Lighting and screen brightness should enable all examinees to read the computer screen in comfort. It should not produce shadows or glare on the computer screen or writing surface.
- The testing room should comfortably accommodate the number of testing stations placed in it.
- Position the computer monitor, keyboard, and mouse properly for ease of use without strain.
- Testing room must be quiet throughout all test administrations. When testing is scheduled, or is in progress, other activities that would disrupt the testing environment should not be conducted.
- Depending on the regulation of the state and country of the testing, the building, testing rooms, and restrooms should be accessible to people with disabilities, including wheelchair access.
- Cell phones that might distract students from the test should be turned off.

ATC21S Directions for Administering "Learning in Digital Networks" Assessments

Note: This guide assumes 50 minutes scheduled for administering EACH scenario. This will consist of a 5-minute instruction period, and a 45-minute test period.

BEFORE ADMINISTERING, you MUST verify the technical requirements at http://bearcenter.berkeley.edu/test/test.html for **each** of the student computers. To do this, login to the link from the student computers and answer all the questions. The answers will be specific to each computer, so if you do not have a standard computer setup, each computer will need to be checked.

Test Administration instructions

In about 5 MINUTES, give students "ASK THREE THEN ME" directions. Every student is expected to explore three sources of information before asking instructor or test administrator help. These three are: (1) task directions and resources on each screen, (2) questions online of team members to get and give help, and (3) access internet for information PRIOR to requesting help. Instructor help is to be RARELY given (see below for instructions on how), and students are to explore and do their best with the information and team members available. Instruct students that collaborating and using the Internet is expected and is NOT cheating for this assessment.

SAY: *"I will provide you with ASK THREE THEN ME directions. Every student is expected to use three sources of information before asking for help. First, you are expected to use task directions and resources on each screen. Second, work with your team members to get and give help. Third, use the internet for information. PLEASE KEEP IN MIND THAT THIS IS NOT CHEATING. Otherwise, you should explore the tasks and do the best you can with the information and team members provided. You are being assessed on YOUR ABILITY to work with tools and people online."*

Provide each student with their correct login and password for FADS (the delivery system).
Write down http://bearcenter.berkeley.edu/atc21s-americas/ **on the board or provide on the paper.**

SAY: *"In the paper handed to you, you will find the login ID and password you need in order to login to the system from the website written on the board (or provided on the paper)* (Give students the name of the practice test to which they are assigned, see the sampling matrix provided by your country representative).

"Now you will login to the system. You will select the task and start the test. (Give students the name of the instrument being delivered. Tell them to select this name on the screen). If you have a SERIOUS technical problem with either the test or the computer, please raise your hand and I will help you. You have 45 minutes. Please pace your time appropriately and do not spend too much time on a particular task."

If students are taking Global Human Legacy Task 2011 (Webspiration poetry), say:

SAY: "*Average time you have for each screen is about 5 minutes. Note that once in Webspiration (Global Human Legacy Task 2011,poetry), you should try to leave the document by selecting **Document>Sign Out**". Otherwise next time the orange box with the link to your document might not appear. Then you will need to find your document under the Recently Opened menu that you will see. If you encounter this problem, ask me for help."*

SET TIME FOR 45 MINUTES. Starting time: __________ Ending time: __________

(Write the "Starting time" and "Ending time" on the board if necessary.)

Note: In RARE cases, if student needs help and CANNOT PROCEED AT ALL during the assessment, administrator may provide assistance. To do so, **FIRST** record information in TeachAid screen available by clicking "*T*" icon in lower right of student screen, **THEN** provide help to student face-to-face. This is primarily for special needs students or to record unusual technical problems that do not occur for most students so that they can be addressed in future versions.

When 45-minute testing period complete:

SAY: "*Please stop working, logout from the system and turn off computers."*

Note: Collect all login and password forms distributed to students earlier. Make sure that all computer hardware used by students during testing is left in proper condition. Do not forget to report any technical issues and testing irregularities to the testing coordinator of your country.

Technical Requirements

BEFORE ADMINISTERING, you MUST verify the technical requirements at http://bearcenter.berkeley.edu/test/test.html for **each** of the student computers. To do this, login to the link from the student computers and answer all the questions. The answers will be specific to each computer, so if you do not have a standard computer setup, each computer will need to be checked.

Task Access:
Web address (for U.S. administration only):
http://bearcenter.berkeley.edu/atc21s-americas/
login and password: see assigned list or contact test coordinator of your country.
Once logged in, select the desired assessment from the list. Note that ATC21S cognitive laboratory passwords are preset to access only one scenario each:
1. Global Human Legacy Task 2011 (poetry)
2. Global Collaboration Contest 2011 (Arctic trek)
3A. Global 2nd Language Chat: Native Speaker
3B. Global 2nd Language Chat: Language Learner
If you are using demo accounts to preview the tasks, make sure you are using the right age level demo accounts.

Technical details:
• devices supported - PC or Mac
• headphones for students and color monitor required
• browsers - PC: IE 7.0+, FireFox 3.0+; Mac: Safari 4.0+, FireFox 3.0+

• browser settings - javascript and pop-up windows must be enabled
• plugin - Adobe Flash 10.3+
• internet connectivity - broadband suggested (1.5Mbit/s or higher)
• screen size/resolution - 1024x768 or higher recommended, works at less
• access to external websites in the tasks
• microphone may be required for some scenarios
• permissions to download files from a browser.
• empty browser caches prior to test administration
• test audio for playing podcasts in advance
• ensure no auto-update software will launch to impede the use of the computer in a timely manner
• ensure that the network performance is adequate:

1. Direct your browser to "http://www.speakeasy.net/speedtest/"
2. Click on "Dallas, TX"
3. Note the Download Speed and Upload Speed. Speed below 1.0Mbs or 0.7Mbs indicates inadequate performance.

Technical Assistance

For ATC21S technical assistance, contact bearit@berkeley.edu. Note that technical assistance will be provided within two business days, with business days/times 10 am-5 pm Monday-Friday U.S. Pacific Standard Time.

HIGHLY CONFIDENTIAL HIGHLY CONFIDENTIAL

ANSWER KEY for ARCTIC TREK CLUES

(answers shown below are confidential)

This answer key is provided for teachers who are previewing the Arctic Trek scenario and would like to check clue answers as they preview the task.

Age 11:

Clue 1*: Arctic Basin is expected -* ***Link:*** *Polar Bear Map.*

Clue 2: *Arctic Fox is expected -* ***Link:*** *Land Animal Food.*

Clue 3: *Answer may be 3 (1 point), 5 (2 points), or 6 (3 points), any other number is no credit.* ***Link:*** *Polar Bear Population.*

Clue 4: *Correct answer might look like the following: "In most places the polar bear population is dropping, so that could be a problem for polar bears"* ***Link:*** *Polar Bear Population.*

For the ***line graph****, a number of lines and sliders can be used. We want to see a reasonable trend showing that approximates the data, and whether students can explain why they used what they used. This task measures ICT Literacy with some quantitative reasoning representations.*

For the ***spinners****, 5 spinner sections are ideal, each section being roughly proportional to the corresponding bars on the graph.*

Kodu*: Whether or not Kodu is installed is an assessment question. Students should attempt to check and answer themselves. Their response will be compared to the information received from the corresponding country. Countries for which Kodu is installed can then continue with the screen.*

Clue 5: *Answer might be similar to: "No, the web screen does not give information to answer this question." For the question about whether it is possible estimate, students should be able to say they cannot estimate by using the Finnish page supplied, but might be able to estimate by using other information resources online, for instance. Their reasoning argument for how to estimate using digital resources will be examined.* ***Link:*** *Finnish Artic club.*

Age 13:

Clue 1: *Barents sea -* ***Link:*** *Polar Bear Map.*

Clue 2: *Any two of the following: Artic Fox, Alopex lagopus, White Fox, Snow Fox -* ***Link:*** *Land Animal Food.*

Clue 3: *Answer may be 3 (1 point), 5 (2 points), or 6 (3 points), any other number is no credit.* ***Link:*** *Polar Bear Population.*

Clue 4: *Correct answer might look like the following: "In most places the polar bear population is dropping, so that could be a problem for polar bears"* ***Link:*** *Polar Bear Population.*

For the ***line graph****, a number of lines and sliders can be used. We want to see a reasonable trend showing that approximates the data, and whether students can explain why they used what they used. This task measures ICT Literacy with some quantitative reasoning representations.*

For the ***spinners****, 5 spinner sections are ideal, each section being roughly proportional to the corresponding bars on the graph.*

Kodu*: Whether or not Kodu is installed is an assessment question. Students should attempt to check and answer themselves. Their response will be compared to the information received from the corresponding country. Countries for which Kodu is installed can then continue with the screen.*

Clue 5: *Answer might be similar to: "No, the web screen does not give information to answer this question." For the question about whether it is possible estimate, students should be able to say they cannot estimate by using the Finnish page supplied, but might be able to estimate by using other information resources online, for instance. Their reasoning argument for how to estimate using digital resources will be examined.* ***Link:*** *Finnish Artic club.*

Age 15

Clue 1: *Barents sea -* ***Link:*** *Polar Bear Map.*

Clue 2: *Snow -* ***Link:*** *Land Animal Food.*

Clue 3: *Answer may be 3 (1 point), 5 (2 points), or 6 (3 points), any other number is no credit.* ***Link:*** *Polar Bear Population.*

Clue 4: *Correct answer might look like the following: "In most places the polar bear population is dropping, so that could be a problem for polar bears"* ***Link:*** *Polar Bear Population.*

For the ***line graph****, a number of lines and sliders can be used. We want to see a reasonable trend showing that approximates the data, and whether students can explain why they used what they used. This task measures ICT Literacy with some quantitative reasoning representations.*

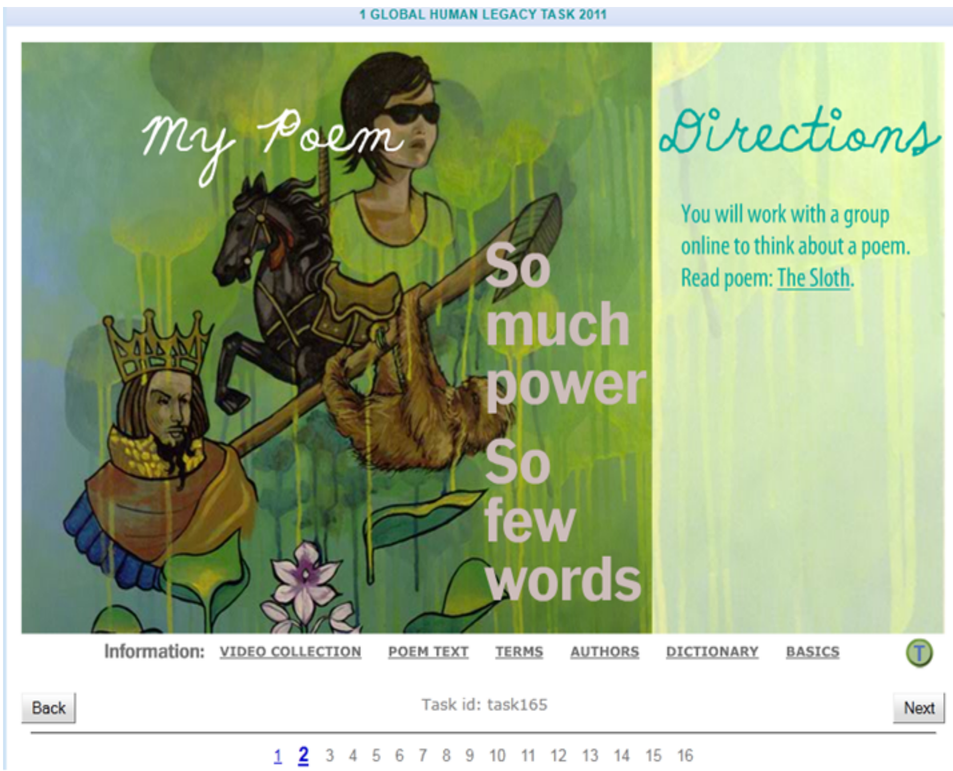
For the ***spinners****, 5 spinner sections are ideal, each section being roughly proportional to the corresponding bars on the graph.*

Kodu*: Whether or not Kodu is installed is an assessment question. Students should attempt to check and answer themselves. Their response will be compared to the information received from the corresponding country. Countries for which Kodu is installed can then continue with the screen.*

Clue 5: *Answer might be similar to: "No, the web screen does not give information to answer this question." For the question about whether it is possible estimate, students should be able to say they cannot estimate by using the Finnish page supplied, but might be able to estimate by using other information resources online, for instance. Their reasoning argument for how to estimate using digital resources will be examined.* **Link:** *Finnish Artic club.*

Some Screen Shot Examples from tasks:

First screens from an example scenario, for your reference. Please see the online preview scenarios you will receive, referenced above, in order to obtain preview access to your practice and assessment screens.



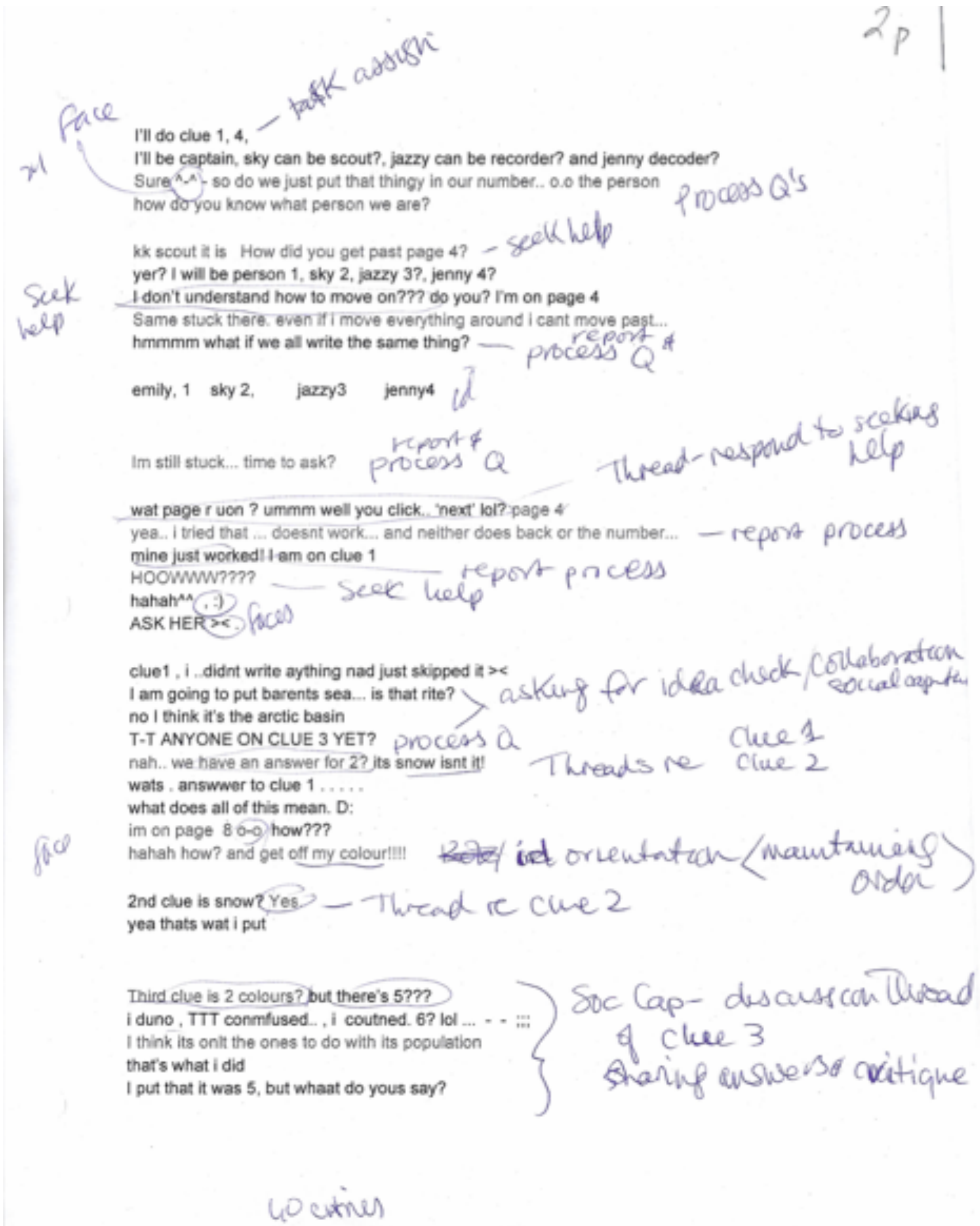

1 GLOBAL HUMAN LEGACY TASK 2011
My Poem Webspiration
A Webspiration Graffiti Wall has been shared with you.
Login and add your ideas.
HOW? Help Podcast.
Team 1, login: demo1 and password: demo1pass
Back
Task id: task167
Next
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

APPENDIX M

SAMPLES OF CODED NOTEBOOKS

Sample of Notebooks Coded Through Qualitative Analysis

Notebook 2


I'll do clue 1, 4,
I'll be captain, sky can be scout?, jazzy can be recorder? and jenny decoder?
Sure ^-^ - so do we just put that thingy in our number.. o.o the person
how do you know what person we are?

kk scout it is   How did you get past page 4?
yer? I will be person 1, sky 2, jazzy 3?, jenny 4?
I don't understand how to move on??? do you? I'm on page 4
Same stuck there. even if i move everything around i cant move past...
hmmmm what if we all write the same thing?

emily, 1   sky 2,   jazzy3   jenny4

Im still stuck... time to ask?

wat page r uon ? ummm well you click.. 'next' lol? page 4
yea.. i tried that ... doesnt work... and neither does back or the number...
mine just worked!! I am on clue 1
HOOWWW????
hahah^^ , :)
ASK HER >< .

clue1 , i ..didnt write aything nad just skipped it ><
I am going to put barents sea... is that rite?
no I think it's the arctic basin
T-T ANYONE ON CLUE 3 YET?
nah.. we have an answer for 2? its snow isnt it!
wats . answwer to clue 1 . . . . .
what does all of this mean. D:
im on page 8 o-o how???
hahah how? and get off my colour!!!!

2nd clue is snow? Yes.
yea thats wat i put

Third clue is 2 colours? but there's 5???
i duno , TTT conmfused.. , i coutned. 6? lol ... - - :::
I think its onlt the ones to do with its population
that's what i did
I put that it was 5, but whaat do yous say?

Sample of Notebooks Coded Through Qualitative Analysis

Notebook 8

8

Entries - 37
Q's - 10
id yes but not formal
Role assign no
Task assign no

Team 1: Type or paste information here for your whole team to see. Use the menus above to format your text or highlight it with notes. To add pictures or to insert web addresses to other sites, use the Insert menu. Feel free to experiment with this tool! You can always delete parts and start over.

Your team's SECRET CODE: XF9

Ok so im waiting for the map to load wt about you guys? me two it taking to long to load to hard to find im looking at all the stuff and its hard to look. a lot of stuff to look at i know and ive been looking at the same thing over and over again but it says nothing about white bears let me know if you find the answer i dont kow the answer ether and going to keep on reading

Found it it was the Laptev Sea and the next was Arctic Fox

My Answer was 5 colors. where did u get tht answer from never mind i know how u got that answer jaime inguez here is anybody else there

You need help - how do you rate ur team

So you put the rate first and then you go and put the other answer after

i dont get it it is really hard to do this this is jose perez

jaime do you get it this is jose - ya wat do you need help on

ay do get what are tring to do here

waagan is on who is jamie thats not how u spell my name waagan its the way jose spelled it

Dominic is Anonymous user 1882

Yea so any way w

e need to fin this what slide you guys on and 8 118 stop fooling around were nt fooling around who ever this is

uZZZZZZZWHOS ERASING IT??????????????????????????? OK SO 7 IS LAPTEV SEA and 8 is Arctic Fox 9 is 5 and 5 10 just rate a good and 6 colors. 11 is 3. 12 is the population and that the bear should worry about the lowering of the population. 13 line three and lowering and raising of population. 14 do by yourself. I dont know what to do for 15 and 16 is no and they cant estimate. 17 is second to the top. and 18 you just give your own opinion and then you're done.hh

Domic what is question 4 because it ask

what question are you on can you help uhhhh 4 is supposed to be u just assign it to any one ok?

hh ?
Jaime
Jose
Dominic

1 of 1 9/23/11 12:54 PM

APPENDIX N

SURVEY OF EDUCATORS

Survey: Teacher Technology Use and Professional Development for CSCL

Experience: How many years teaching: grade levels:

Technology (Circle all that apply)

I was trained in Information Communication Technology:

pre-service in-service through district sought training on my own no training in ICT

Do you use technology at home?

Computer laptop handheld device other Frequency?

Do you use technology at school?

Computer laptop handheld device other Frequency?

Do you use technology with your students?

Computer laptop handheld device other Frequency?

How do you currently evaluate your student tech work, if applicable?

Cooperative Learning: (circle all that apply)

I was trained in Cooperative Learning:

pre-service in-service through district sought training on my own no training

I use cooperative learning components in my classroom instruction

Yes No Frequency:

Collaboration:

I use collaborative working arrangements with my students

Yes No Frequency:

I do collaborative work in a technological setting in my personal life

No Yes Google docs wikis blogs prezis animoto other tech tool/program

Please state other:

I do collaborative work in a technological setting in my professional/school site setting

No Yes Google docs wikis blogs prezis animoto or other tech tool

Please state other:

I use collaborative work in a technological setting with my students

No Yes Google docs wikis blogs prezis animoto or other tech tool/program

Please state other:

If not, why not?

Lack of technology lack of time (other curricular needs) age of students

I don't feel proficient/confident to teach these skills other (Please describe)

Social-Emotional Learning:

I was trained in SEL:

pre-service in-service thru district sought training on my own no training in SEL

I teach SEL skills to my students: As needed Regularly Frequency:

I feel confident teaching social-emotional skills to my students Yes No

I have a curriculum for SEL (please name)

21st Century Skills:

I have seen or could identify a framework for 21st century skills Yes No

Professional Learning Communities (PLC's)

I participate in a / some PLC's through:

school site district a professional organization

APPENDIX O

ACADEMIC SOCIAL EMOTIONAL LEARNING STRANDS

Academic Social Emotional Learning Strands (Casel, 2003)

Strand	Elements
Self awareness	Recognizing one's emotions and values as well as one's strengths and limitations, self efficacy
Self management	Managing emotions and behaviors to achieve one's goal, impulse control and stress management, self-motivation and discipline, goal setting and organizational skills
Social awareness	Perspective taking, showing and understanding empathy for others, appreciating diversity, and having respect for others
Relationship skills	Communication, social engagement, building relationships, working cooperatively, negotiation, refusal, and conflict management, help seeking and providing forming positive relationships, working in teams, dealing effectively with conflict
Responsible decision-making	Problem identification and situation analysis, problem solving, evaluation and reflection, personal, moral and ethical behavior, and making ethical, constructive choices about personal and social behavior

APPENDIX P

TECHNICAL AND INTER-RATER STUDIES

Rubric inter-rater exploration. The rubric used to score the Notebooks was developed using the Body of Work Method and Discourse Analysis as described above. In order to increase the content validity and technical adequacy, a draft rubric was sent to professionals in the field for review of the components. Professional selection was comprised of at least one expert from research in communication, collaboration or digital collaboration, and one expert from practice in middle level through high school teaching. Correspondence theory and matching were used to sample the evidence of student work in the Notebooks documenting student use of the ATC21S construct components along with coherence theory, matching the evidence to the emergent theory and relevant literature for theory testing (Shadish, Cook & Campbell, 2002).

Rubric technical adequacy. Referring to the American Psychological Association Standards for Testing (2002), several methods were used to estimate the evidence quality of the rubric.

Criterion validity. Criterion validity of the rubric was established through work in Phases 1, 2 and 3 with iterative review of student work sample characteristics against described Traits on the rubric, including the review of inter-raters.

Inter-rater reliability. The Body of Work scoring and range finding process was replicated with eight inter-raters purposively chosen from the field in order to check for alternative ideas about proficiency; this is discussed further in the following sections. Performance levels were then narrowed in the pinpointing phase, designating levels of proficiency as per completion of stated assessment tasks. Purposive sampling was used to select Notebooks and raters for the inter-rater comparison. Approximately 25% of the Notebooks (eight) were purposively sampled for cross-rater analysis. Notebooks were selected for a teachable purposive sample reflecting differentiated patterns of skill development to represent different instructional levels. Notebooks patterns of skill development were based on initial placement regarding low to high collaborative skill as determined through the Body of Work method. Saturation evaluation analysis based on Discount Usability Engineering or Heuristic Evaluation Quality Scoring (HEQS) was used to add raters from an initial three to a maximum of eight, depending on when information function begins to stabilize. Research on Discount Usability Engineering and HEQS holds that after four raters, a substantial amount of additional new information is rarely gathered (Kirmani, 2008; Nielsen & Landauer, 1993) In this study, eight raters were involved in the inter-rater process, three in an asynchronous format, and five in a moderated session; the eight workbook samples were each reviewed by the eight raters. See below for descriptions of the rating session processes

Purposive raters. The sample frame of raters were chosen to reflect the different experience-based perspectives available in education and the number of raters that provide the highest level of new information. The crossover perspective, blending years of practice with doctoral level study can be represented by the author of this study. Other perspectives include the research and higher education perspective and the K-12 professional practice perspective. At least one rater with backgrounds in research and higher education and one rater with experience in practice teaching at the middle to high school level were included. Descriptive statistics were used to look at the trends between raters.

Administration procedures. In addition to statistical reliability estimates, administration of the rubric included administration instructions that constrained the respondent's frame-of-reference regarding the student work considered when completing the rating. Notebooks remained deindentified as to age and regional source so as not to bias the review.

Differentiated rating situations. Raters were recruited for both remote location asynchronous rating and a face-to-face rating session. Three asynchronous raters were sent a packet with rubric administration instructions that included background information on the assessment along with eight samples and a sheet to record their results. They took a survey, shown in Appendix N, regarding their professional development and classroom use of strategies in the areas of collaboration, technology, and computer-supported collaboration. Asynchronous raters were not in touch with other raters, and did not have a practice-rating sample with feedback.

Moderated rating session. Following the use of the rubric by educators serving as asynchronous inter-raters, a trial was established using a face-to-face, moderated group of educators gathered in Eugene, Oregon. Five educators met after school to review the purpose and structure of the assessment task, review the rubric, and practice-rate two samples with moderation. Face to face raters received the same administration instructions and background information on the assessment as asynchronous raters. Following the practice rating, teachers discussed the scores they gave with other teachers and came to agreement about student sample elements that met rubric traits. Questioning and clarification of traits occurred using the samples rated (Notebooks 32 and 33). Educators then individually rated the same eight samples the other inter-raters used.

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