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A comparative study of the effect of collaborative problem solving in a massively multiplayer online game (MMOG) on individual achievement

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A COMPARATIVE STUDY OF THE EFFECT OF COLLABORATIVE PROBLEM-SOLVING IN A MASSIVELY MULTIPLAYER ONLINE GAME (MMOG) ON INDIVIDUAL ACHIEVEMENT

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This dissertation, written under the direction of the candidate's dissertation committee and approved by the members of the committee, has been presented to and accepted by the Faculty of the School of Education in partial fulfillment of the requirements for the degree of Doctor of Education. The content and research methodologies presented in this work represent the work of the candidate alone.

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Dedication

This is dedicated to my Lord and Savior Jesus Christ through whom all things are possible. I would also like to dedicate this work to my husband Rick, my soul mate and best friend. Thank you for your prayers, your unwavering support, and many words of encouragement. Thank you for the reminders to step away from my work to enjoy down time and thank you for your gentle nudging when I thought that I couldn’t push forward.

I also dedicate this work to my children Myisha, Richard, Lindsay, Jamie, and Timothy. Thanks for letting me know in your own special ways that you were proud of my efforts and accomplishments. You guys bring me so much joy.

Finally, I dedicate this work to my dad, Sam Marshall Sr. who went home to be with the Lord in 2002. Dad, you planted within me the desire to pursue lifelong learning I know that you are celebrating with me. Mom, you make me feel as if I can accomplish anything. Thank you for believing in me.

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Abstract

Since the early 2000s, significant attention has been given to the academic potential of a new type of online game called Massively Multiplayer Online Games (MMOGs) that take place in 3-dimensional (3D) immersive persistent worlds. MMOGs are believed to hold significant promise for educators because they provide for the player (learner) rich learning opportunities that exemplify quality-learning experiences but there is little empirical research and published work on MMOGs. The purpose of this study was to investigate the impact of collaborative problem solving during MMOG play on the individual achievement (post test and concept-map construction scores) of 159 sixth-grade students. There were four comparison groups of existing, intact sixth-grade classes (n=100), 2 taught by the researcher and 2 taught by the regular sixth-grade science teacher and an experimental group of two existing, intact sixth-grade classes (n=59) taught by the researcher. During the 8-day investigation, the experimental group played *Web Earth Online,* an ecology-based MMOG, and the comparison group received traditional instruction that included multimedia-rich, hands-on, collaborative, activities to learn about the life cycle and survival needs of the Eastern Bluebird. A content analysis of the log files of player dialog to assess player collaborative teamwork during MMOG play was utilized. A dependent-samples t test and an analysis of variance (ANOVA) was utilized to examine the differences in performance between the experimental and comparison groups on the content knowledge assessment and concept-map construction task. A correlation of frequencies was utilized to examine the relationship between collaborative teamwork-strategy scores of students in the MMOG group and posttest and concept-map scores. Satisfaction surveys were administered to examine game and unit satisfaction.

Results of the analysis showed that individuals who participated in the experimental group tended to have statistically significant *lower* posttest scores than students in the comparison group taught by the researcher (based on the 33-item test results) or in the comparison group taught by the teacher (based on the more reliable 17-item test results). Although no statistically significant differences were found in the scores from the experimental group, a statistically significant difference between pre-and-posttest scores was found for the whole sample. Descriptive statistics indicated that learning growth occurred in both groups as evidenced by the pre-and-posttest difference in means.

Moreover, nonsignificant differences among the three groups in terms of concept map scores were observed. An analysis of the chat log files of the MMOG participants revealed that only 30% of the chats involved collaboration, with the more common strategies being Communication, Leadership, and Interpersonal. A statistically significant positive correlation was found between usage of Leadership strategies and posttest scores. Findings from correlation results show that there is a high degree of interitem correlation between the collaborative strategies identified for the study from the chat log files of the experimental group.

The percentage of responses of agree and strongly agree that participants learned from the MMOG and the instructional unit are 82%, 58%, and 75% for experimental, researcher’s comparison and teacher’s comparison, respectively, with the experimental students overwhelmingly indicated they learned about the Eastern Bluebird.

The findings from this study suggested that the educational use of video games, specifically MMOGs, can be a viable pedagogical strategy. Results indicated that *Web Earth Online* was engaging and motivating for students and that the study indicated that concept maps are appropriate instruments to measure learning in a MMOG. Because of the growth in learning in both groups a claim can be made that the rich learning experiences in the comparison groups provided a situated-learning environment (authentic context, authentic activities, authentic assessment, expert modeling, and situated mentoring) that was very similar to the experiences of students in the experimental groups.

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CHAPTER
I. INTRODUCTION

Is the use of a Massively Multiplayer Online Game (MMOG) a viable pedagogical strategy? Does collaborative problem solving within a MMOG environment enhance individual achievement? This proposed study addresses these questions.

The concentration on the educative value of video games has escalated since the late 1990s. This phenomenon is evidenced by the large volume of literature that has been generated in the entertainment, military, academic, and business sectors acclaiming its positive effect on learning and its potential as an instructional tool (Bonk & Dennen, 2005; Bowen & Morrison, 2005; Chappell & Stitt, 2005; Foreman, 2003 July-August; Halverson, 2005; Jenkins & Squire, 2003; Oblinger, 2004; Oreovicz & Wankat, 2005; Prensky, 2001a, 2001b; Stafford, 2005).

Numerous popular press articles, books, and scholarly *think pieces* tout other benefits of the use of video games such as knowledge acquisition, retention, recall of factual content, creative and critical thought, decision making, the development of strategic skills, and problem solving (Aldrich, 2004, 2005; Beck, 2004; Foreman, 2004 September-October; Gee, 2003, 2005a, 2005b; Jenkins & Squire, 2003; Johnson, 2005; Lieberman, 2006; Prensky, 2000, 2006b; Squire, 2005). Mitchell and Savill-Smith (2004) reported that game playing assists learners in adjusting to other computer-oriented learning tasks, interpreting iconic representations (on-screen images), and enhancing spatial awareness (knowing where things are in relation to other things).

Given the burgeoning list of positive acclaims of video-game play in education, the focus of many scholars, researchers, and educators has been to set aside the question of *whether* video games should be integrated into an educational context. The focal point now is the investigation of what skills are gained through video-game play and what elements of game play can be activated and transferred within an instructional context to produce meaningful classroom learning experiences.

Statement of the Problem

All video games are not equal in regard to the type of learning experiences that they afford learners, but key characteristics of effective video games surface consistently in the literature. Researchers suggest that the challenge of problem solving (a cognitive process directed at achieving a goal when a solution method is not obvious to the problem solver) is one of the key learning outcomes of a computer-mediated situated environment such as video games (Egenfeldt-Nielsen, 2007; Gee, 2003, 2004; Potter, 1999; Prensky, 2000, 2001b). Steinkuehler (2006) concluded that “deep-play” game environments consist of well-defined (clear initial state, defined goals, and a simplistic path to solution) problems nested within ill-defined (no clear initial state or defined goals) problems. This “deep play” incorporates important characteristics of traditional problem solving such as problem presentation, goals, strategies, and collaborative contributions such as debriefings and apprenticeship.

Other researchers emphasize that enhanced metacognitive (conscious about one’s thinking) skill development, a component of problem solving, such as decision making, self-regulation, information-seeking, and self-checking, is evident in certain types of video-game play (Baker, O'Neil, & Wainess, 2005; Braswell & Childress, 2006; Dede & Ketelhut, 2006; Fernandes, Ritterfeld, Vorderer, & Weber, 2004; Ko, 2002; Laughlin & Marchuk, 2005; Ritterfeld & Weber, 2006; Steinkuehler, 2006). These skills assist players who face unfamiliar situations and increasing challenges as they move through game levels. Another aspect of video-game play that adds an important dimension to the learning process is the fostering of teamwork and interaction through active problem solving in an immersive-play environment (Fernandes et al., 2004). This collaboration between novice players and more experienced players to define problem-solving goals and means enhances learning as players share the collective intelligence of the group to solve problems (Abram, Cohen, Lotan, Scarloss, & Schultz, 2002; Steinkuehler, 2006).

Since the early 2000s, significant attention has been given to the academic potential of a new type of online game called MMOGs that take place in 3-dimensional (3D) immersive persistent worlds (permanent virtual worlds where the game is continually accessible online and player avatars (a real person's online alter ego) are actually citizens of the world). MMOGs are believed to hold significant promise for educators because they provide for the player (learner) rich learning opportunities that exemplify quality learning experiences. Quality learning experiences that are highlighted in the literature are highly collaborative, anchored in the real-world, incorporate challenges to solve well-defined and ill-defined problems, provide opportunities for metacognitive development, and a high level of student engagement (Braswell & Childress, 2006; Dede & Ketelhut, 2006; Gee, 2003; McCreery & Schrader, 2007; Schrader, Young, & Zheng, 2006; Steinkuehler, 2006).

Although the educative value of the use of video games such as MMOGs in an academic setting is promising, writers and scholars cite the need for more empirical research on the cognitive benefits of video-game play (Durkin, 2006; Gerhard & Göth, 2005; Ritterfeld & Weber, 2006; Steinkuehler, 2006). There is even less empirical research and published work on the use of newer-generation immersive MMOGs, the focus of the current research, that appear to hold even greater promise.

Purpose of the Study

The use of video games as learning tools in the classroom appears to hold promise in education. Scholars and researchers contend that video games are viable agents to enhance current classroom instructional strategies by providing learners with opportunities to create, experiment, interact, share, and problem solve. Many proponents of the use of video games in education claim that MMOG play holds particular promise because of the complex problem solving that takes place through player collaboration. The benefit and significance of collaborative game play through the embedded support mechanisms within MMOGs to master game levels and solve problems are emphasized in much of the literature on MMOGs (Braswell & Childress, 2006; Clarke, Dede, Ketelhut, & Nelson, 2006; Freitas, 2006; Jenkins & Squire, 2003; McCreery & Schrader, 2007). Organic teaming happens as players' individual information and inquiries intersect. This ongoing collaboration leads to enhanced player performance, higher retention of information, and enhanced performance in solving complex problems (Jenkins & Squire).

The purpose of this study was to investigate the impact of collaborative problem solving during MMOG play on the individual achievement of sixth-grade students. The MMOG (*Web Earth Online*) was an ecology-based game that focused on the survival needs of bluebirds within an authentic habitat. An assessment of the types of collaborative strategies that participants use during game play and the performance of individual players after game play on measures of academic achievement (concept-map construction and pre- and posttest performance) on life-science concepts (life cycle and survival needs of bluebirds) was conducted. Performance of game players was contrasted against the academic-achievement performance of a comparison group receiving traditional instruction.

Situated learning theory that advances the idea that authentic learning takes place in real-life, problem-solving contexts and The CRESST researchers' model to classify video-game collaborative problem solving (collaborative teamwork strategies) (Baker, et al., 2005) was utilized in this study. This research also may provide insight into the practical considerations of integrating video games into the curriculum in which teachers are interested (Heald, McFarlane, & Sparrowhawk, 2002; Rice, 2007; Schrader et al., 2006).

Background and Need

Technology in Education

Researchers have studied the impact of technology on learning since the 1970s (Lin, Michko, & Waxman, 2003). The focus of the research has centered on a variety of areas including the use of computer-assisted instruction, the academic benefits of particular hardware and software, and the benefit of technology tools for specific populations (Kelley & Ringstaff, 2002; Lin et al.). Recent research suggests that technology can have a positive impact on student learning, engagement, and collaboration (Kelley & Ringstaff; Lin et al.).

The results of a recent meta-analysis that synthesized the results of 42 studies suggest that the overall cognitive, behavioral, and affective effects of instructional use of technology to support learning are greater than what was anticipated previously in earlier meta-analyses (Lin et al., 2003).

Two of six critical factors for effective implementation of instructional technology that Kelley and Ringstaff (2002) summarized from their analysis of the literature favoring longitudinal studies are that technology should be integrated into curricular frameworks and that technology should be viewed as a component of a much broader school-improvement effort. Both Kelley and Ringstaff and Lin et al. (2003) pointed to the rapid evolvement of technology and indicated a need for further research on how to integrate appropriately new, interactive technologies such as videogames and MMOGs. They also call for research to investigate under what conditions do students gain the most benefit from the instructional integration of these tools. The current study adds to the body of research on these important questions.

Video-game Industry

Video-game sales have risen sharply since the late 1980s (Entertainment Software Association, 2006a, 2006b). Currently a multibillion dollar industry (Entertainment Software Association, 2006b; Oblinger, 2004; Squire, 2005), market analysts predict that videogame sales will continue to escalate (Chappell & Stitt, 2005) surpassing box-office sales and predicted to surpass music and video-rental sales. Another smaller but growing video-game market (a 20 million dollar industry) is *Serious Games*; (Backlund, Johannesson, & Susi, 2007).

In 2002, the Serious Games Initiative, an initiative focused on the application of video games for purposes other than entertainment, began to resurge (Annetta, Bohr, Laird, Murray, & Park, 2006; Backlund et al., 2007; Sawyer, 2007). This initiative led by scholars encouraged developers to design games for the business, healthcare, government, and education sectors that concentrated on themes such as social, humanitarian, health issues, military simulations, and business training (Annetta et al., 2006; Sawyer, 2007).

The purpose of all *Serious Games,* many that are MMOG-type, such as *Web Earth Online*, the focus of the current study, is to provide high-quality teaching through engaging game play (Annetta et al., 2006; Backlund et al., 2007). This growing video-game industry subgroup has the potential to remove persistent barriers to the use of video games in education by developing pedagogically sound games that educators can embrace. These games are also viewed as meeting the needs of today's learners; however, more empirical research is needed to support these assumptions.

Digital Natives

According to many forerunners of the new-generation digital-gaming era, 21st-century school-age gamers, often referred to as digital natives because of their fluency in the language of digital technology tools, such as the Internet, computers, and video games, bring high-level digital savviness to the classroom because of their gaming experience (Aldrich, 2005; Gee, 2003; Prensky, 2000).

Forty-six percent of students under 18 are ardent users of video games; an average eighth grader's weekly play totals more than 5 hours per week (Entertainment Software Association, 2006b; Katsionis, Manos, & Virvou, 2005; Oblinger, 2004). In 2003, more than 69% of high-school students reported to have played video games since elementary school. The majority of adult gamers have played for more than 12 years (Entertainment

Software Association, 2006b) supporting Oblinger's findings that most gamers have engaged in game play since elementary school.

Students are enthusiastically embracing all types of digital technologies, albeit at various rates and levels of expertise. Because of the ubiquitousness of digital technologies such as video games and their high-volume use by today's learners, researchers believe that students' thinking patterns have changed and that these new thinking patterns surface in (Barnes, Ferris, & Marateo, 2007; Bowen & Morrison, 2005; Prensky, 2001a; Seal-Wanner, 2007) classrooms across the country. Educators are grappling with how to respond to this wave of new learners.

These learners expect learning experiences that are interactive, offer varied feedback mechanisms, provide assignment choice, provide immediacy to information, are hands-on inquiry-based and experiential, respect and allow multitasking, encourage social networking, and provide opportunities for creative expression.

Important 21^{st}-century skills that MMOG players bring to the classroom are problem-solving, collaboration, and communication. Many writers suggest that teachers should leverage the skills that students are learning outside of school such as what is learned in video-game play by incorporating them into a framework of clearly defined instructional goals (Barnes et al., 2007; Corbit, 2005; Klopper, 2005 July-August; Oblinger & Oblinger, 2005); however, from the perspective of many teachers, the potential of video games to support learning is not evident.

Teacher Perceptions of Video Games

There is skepticism as to the educational benefits and potential of game-based learning (Jenkins & Squire, 2003; , 2005; Kirriemuir & McFarlane, 2006; Lee, Luchini, Michael, Norris, & Soloway, 2004 April; Rice, 2007) often expressed by educators. Educators are not certain that their investment in time and resources to implement video games will meet the needs of learners and assist learners in mastering content (Black, Boyer, Dipietro, & Ferdig, 2007). In addition, educators are not convinced that video games, typically associated with entertainment and motivation tools, can serve as educational tools (Schrader et al., 2006). Furthermore, some teachers view video games solely as a tool for behavior modification (reward system) rather than a legitimate pedagogical agent.

Teachers' lack of understanding of the distinct characteristics of old-generation (arcade-style) and the new-generation (immersive, real-world, complex, knowledge-embedded) video games is a barrier to the integration of video games. The mental impression of the term *video game* for many teachers is mindless *Pac-Man*-style playing disconnected from learning goals or game play cultivating violence (Rice, 2007). Other education professionals hesitate to integrate video games into the instructional program because their integration would necessitate higher-level technology expertise, often with steep learning curves and an approach to classroom instruction that is more experiential and less teacher-directed (Rice).

Teachers who are amenable to the classroom introduction of video games because of the perceived academic benefits afforded through game play, want games that are aligned or can be adapted to academic-content standards with minimal time and effort and need guidance in understanding and selecting teaching strategies that complement and extend the learning through video-game play. Another important consideration from the literature is the prohibitive nature of the duration of typical video games. To effectively integrate video games, consideration needs to be given to the design of games that are shorter with fewer objectives that fit into the time constraints of a traditional school day (Rice, 2007).

In order for teachers to view video games as viable instructional means and for teachers to see the significant pedagogical breadth and benefit to student learning that video games such as MMOGs provide, it is essential that the perceptions and the critical questions they raise be addressed in further empirical research such as the current study.

MMOGs in Education

MMOGs evolved from multiuser dungeons (MUDs). MUDs are text-based computer interfaces where players explore virtual environments through their online player-created avatars or characters (Braswell & Childress, 2006). Tasks such as solving puzzles or quests to conquer mythical beings are embedded in MUD game play. The development of more robust computer infrastructures (e.g., increased broadband access, computer processor speed, and enhanced graphic technologies) led to the development of the first high-quality 2-D and 3-D games in the early 2000s. MMOGS vary in quality (e.g., graphics, sound, user interface, challenge, feedback) and genres (e.g., adventure, action, simulation, sports, fantasy). Some MMOGs such as the *World of Warcraft* and *Halo* have the ability to support simultaneously 1,000s of game players and others less than 100.

Key findings in Freitas' (2006) literature review of game-based learning suggest that MMOGs are a powerful modern game because they deeply immerse players into varied settings where they face multiple complex situations and conflicts within a collaborative environment. They are experience-based, engaging, exploratory, and problem-based with identification with avatars being central to learning; and they provide new opportunities to examine the learning process.

In video-game play, the learning of the skills is secondary, and the playing of the game is primary (deep learning of the skills occur through playing the games; Correa et al., 2003). In higher-level games, the objectives are hidden while the activity is driven by discovery, exploration, and adventure (Kirriemuir & McFarlane, 2006).

Jenkins and Squire (2003) described the experience of playing a MMOG as solving a word problem where players draw upon interwoven information from elements within the virtual world to complete tasks based on each players' goals. The distinction between the virtual world and the word problem is that, within, the virtual world, there is less irrelevant information than what is seen in a classic word problem and players naturally engage in ongoing collaboration. For example, in a historical role-playing MMOG called *Revolution,* Jenkins and Squire described how players (blacksmith, bankers, farmers) lend the social, political, and economic perspectives to online and offline decision making and discussions during game play, highlighting the authentic, problem-based facets of MMOG play. Galarneau (2005) describes the complex in-game interaction that is seen in highly popular MMOGs such as City of Heroes® and Second Life®, as *symbiotic.*

In the current study, as players engaged in interactive game play and shared the knowledge and skills that they gained with other players, the collaborative online problem solving dialog was analyzed using CRESSTs' collaborative teamwork processes framework to assess the types of collaboration that took place during problem solving.

The exploration of the use of MMOGs in educational settings is in its infancy but researchers and theorists suggest that the highly social, real-world learning experiences (e.g., assuming the role of a geologist or historian) that are created in virtual environments and the opportunities to interact in real-time within these environments to maneuver challenges, can lead to innovative teaching models that foster problem solving, critical-thinking skills, and raise motivation and achievement levels (Black et al., 2007; Braswell & Childress, 2006).

Theoretical Rationale

Two theories serve as the theoretical underpinning of the current research: situated learning and the CRESST model of problem solving. Situated learning advances the idea that authentic learning takes place in real-life, problem-solving contexts. Proponents of situated learning contend that computer-mediated learning is one approach to immerse learners within these authentic contexts (Gee, 2004; Herrington & Oliver, 1999, 2000; McLellan, 1996). Researchers have indicated that problem solving is one of the learning outcomes of a computer-mediated situated environment (Gee, 2003, 2004; Potter, 1999; Prensky, 2000, 2001b). The CRESST model identifies elements of problem solving, specifically, collaborative problem-solving teamwork processes that can be measured within a computer-mediated environment (Hsieh & O'Neil, 2002; O'Neil, 1999; O'Neil & Schacter, 1997).

Situated Learning

Situated learning theory suggests that knowledge acquisition is a dynamic process where learning is *situated* within the culture and context in which it occurs (Lave & Wenger, 1991; Wenger, 1998). Situated learning contrasts with traditional modes of classroom-learning activities characterized by the delivery of abstract concepts taught in isolation (Brown, Collins, & Duguid, 1989) . Brown et al. asserted that no meaningful learning occurs unless it is embedded within the physical and social context within which it will be used.

The social aspect of learning is foundational in situated learning because it is within the social context that the formation of a “community of practice” takes place (Ducheneaut & Moore, 2005). This community of practice consists of novice and expert participants mutually engaged in common activities that are both dynamic and fluid. The “cognitive-apprentice” stage develops within the community of practice as novice learners acquire behavioral and cognitive skills through cultural immersion and timely support from the masters within the community (Liu & Pedersen, 2003). Just like traditional craftsmen who learn a trade by modeling the behavior of skilled practitioners, these novice learners gradually move from the outer realms of the community as they learn tasks, vocabulary, and organizing principles of the community of practice to become fully participating expert practitioners and valuable contributors to the community (Lave & Wenger, 1991). A simplistic example of cognitive apprenticeship is the experience of a language learner who travels to be immersed into the culture and traditions of the country where the language is spoken. Through observation and interaction with native speakers and enthusiastic participation in daily activities and routines that mirror those of the regular citizens, the language learner gains facility in the use of the language.

Situated-Learning Characteristics

Herrington and Oliver (2000) summarized the critical characteristics of situated learning based on their review of the literature of which many other researchers agree although subtle variations in terminology exists (Bowman, Clarke, Dede, Ketelhut, & Nelson, 2004; Brown et al., 1989; Farruggia, Gieselman, & Stark, 2000; Hendricks, 2001; Herrington & Oliver, 1999; McLellan, 1996). Six characteristics of situated learning emerged: authentic context, authentic activities, authentic assessments, expert modeling, situated mentoring, and legitimate peripheral participation. Authentic context reflects the way knowledge will be used in real life. Creating realistic real-world experiences with complexities and benefits that exist within a nonsimplified physical environment are elements of an authentic context. Authentic activities are relevant, ill-defined rather than scripted, collaborative, sustained over time, and include multilevel tasks. Authentic assessment is integrated within the activities, uses multiple indicators of learning, is valid and reliable, and assesses higher-order skills. Expert modeling provides access to various levels of expertise and observation of real-life episodes that demonstrate expert thinking. Situated mentoring includes an element of "just in time support" and scaffolding at critical times then fading of the expert support. Legitimate, peripheral participation involves actions and interactions of novice and expert learners and an opportunity to examine and re-examine resources to assist learners in finding and internalizing meaning thereby gradually increasing participation in communities of practice. Recent literature identifies one characteristic of situated learning that incorporates four of Herrington and Oliver's characteristics (Bowman et al., 2004); therefore, for the purpose of this study, the *legitimate peripheral participation* characteristic replaces the following Herrington and Oliver's characteristics: *multiple roles and perspectives*, *collaborative construction of knowledge*, *reflection to enable abstractions to be formed*, and *promote articulation to enable tacit knowledge to be made explicit*.

McCreery and Schrader (2007), in their survey study of 2,140 active MMOG players, investigated the novice-expert relationship among levels of expertise and game-related behavior in MMOGs. Results indicated that success in acquiring the necessary skills to solve complex problems during game play is dependent upon in-game mentoring and collaboration, especially for novice game players. This complex problem solving within gaming environments, such as MMOGs, engages players at a high level. Jenkins and Squire (2003) referred to in-game mentoring as *meta-gaming.* Examples of meta-gaming components are ongoing peer-to-peer question-posing, strategy-sharing, expert-player supporting, and combining of collective knowledge to solve complex problems.

Unlike traditional didactic pedagogical techniques where learning is viewed as an individualized activity, game worlds are living, breathing interactive learning experiences that encourage collaboration and interdependence. Skills and information are learned in conjunction with practice rather than in isolation. Numerous opportunities to work together lead to a collective mastery of knowledge through the blending of individual knowledge with the added knowledge of others. Learning is maximized through online role-play performances rather than an over reliance on talking or reading (Delwich, 2006). Players engage in real warfare, compete for territory, build viable economic infrastructures, and diagnose and treat virtual patients. In addition, an important affordance of game play that should be evident in any educational environment is the ability to make and correct mistakes within an atmosphere of safety.

Because of the structure of learning within games such as MMOGs, the time needed to build the community of practice as compared with a traditional academic setting may be diminished greatly (McDermott, Snyder, & Wenger, 2002). Learning begins immediately in game worlds because engagement in practice with timely collaborative support happens at the inception of game play. There is minimal direct instruction, multiple opportunities for trial and error, in-game scaffolding, just-in-time information resources, and instantaneous connection to the relevancy of tasks. Based on these contentions, the current research study that immerses students into 415 minutes of game play is sufficient to build a community of practice.

Many theorists argue that the communities of practice within MMOG play overlap with real-life professional communities of practice (Ducheneaut & Moore, 2005; Galarneau, 2005). For example, in the current study, participant knowledge and interactions gained in an ecology-based MMOG about bluebird survival can be translated to real-life bluebird communities of practice in activities such as bluebird conservation. McDermott et al. (2002) argued that it is not necessary for game-world experiences to simulate the “real world” with complete accuracy in order for meaningful learning to take place. In fact, many experiences in game worlds are not possible in the real world (e.g., dying and being reborn within minutes after your bluebird avatar succumbs to a black rat snake attack). They further argued that education experiences should not be closed designs that do not provide connections to communities outside of the experience. A blending of the within game and outside-of-game communities of practice creates a rich exchange of information that supports learning. Distributed knowledge that is shared within game play is mirrored in real-world communities of practice. The key consideration in game design is for games to incorporate relevant experiences within game play that include salient aspects of the practice community.

In the current study, the learning experiences through MMOG play provided an opportunity for participants to glean from the distributed knowledge of other players (e.g., how to build an adequate nest, how to attract a mate for breeding) to augment their chances of survival as a bluebird. These in-game communities of practice benefit from expert-knowledge interactions and information exchange with real-world community practitioners such as ornithologists or bluebird conservationists.

Problem Solving

After a comprehensive review of the literature, O'Neil and Schacter (1997) contended that consensus does not exist in the information processing, cognitive, and sociocultural literature on the definition of problem solving. For the purposes of this current study, Mayer and Wittrock's (1996) definition of problem solving is utilized. Mayer and Wittrock defined problem solving as a cognitive process directed at achieving a goal when a solution method is not obvious to the problem solver (p. 47). Zhang (1998) defined collaborative problem solving as problem-solving activities that involve interactions among a group of individuals. For the purpose of this research, the CRESST problem-solving model and CRESST taxonomy of collaborative teamwork strategies will serve as the theoretical underpinning of this study.

CRESST Problem-solving Model

The CRESST model of problem solving is derived from the CRESST model of learning and consists of three elements: (a) content understanding, (b) problem-solving strategies (domain dependent or domain independent), and (c) self-regulation. The six elements of the CRESST collaborative teamwork process model are (a) adaptability, (b) coordination, (c) interpersonal, (d) decision making, (e) leadership, and (f) communication.

Content understanding involves explanation of concepts. Learners demonstrate content understanding through performing tasks within varied subject domains, particularly in history or science, that are assessed with a variety of measures (Baker et al., 2005; Chuang, Chung, & O'Neil, 2003; O'Neil & Schacter, 1997). Problem-solving strategies are the intellectual tactics used to solve problems (Chuang et al., 2003; O'Neil & Schacter). These strategies are domain dependent, defined as strategies associated with a particular subject area or domain independent indicating a strategy that can be utilized across multiple subjects. The design of a simulation in order to infer information or the creation of analogies to understand abstract concepts and the construction of concept maps are examples of domain-independent problem-solving strategies. An information-seeking, problem-solving strategy employed to assist a learner in finding a solution to a particular problem is an example of a domain-dependent problem-solving strategy. According to O’Neil and Schacter, content understanding and problem-solving strategies are best assessed domain-dependently, whereas metacognition and motivation are better assessed domain-independently.

O'Neil (1999) partitioned self-regulation into two elements: metacognition and motivation. Metacognition is comprised of planning and self-checking, and motivation is comprised of self-efficacy and effort (O'Neil & Herl, 1998). Planning, an essential metacognitive step, is the establishment of goals and the construction of a plan to achieve them. Self-checking is the mechanism that is in place to monitor progress toward achieving goals. Bandura (1997) defined self-efficacy as the confidence that an individual has in his or her capability of accomplishing a particular task. Effort is the level of energy that one exerts to achieve a task.

The collaborative problem-solving model designed by Chung and O'Neil (1997) includes the aforementioned elements of problem solving as well as the following six CRESST teamwork-strategy components: adaptability, coordination, decision making, interpersonal, leadership, and communication. *Adaptability* refers to a group's ability to identify and respond to problems appropriately. *Coordination* occurs when a group's resources, activities, and responses are organized in such a way that tasks are completed on time. *Decision Making* is a group's ability to make use of all available information and to make decisions accordingly. *Interpersonal* refers to a group's use of cooperative behavior in interacting with members of the team. *Leadership* is demonstrated when members of the group provide direction for the team by planning and organizing, distributing tasks, and evaluating group performance. *Communication* is a group's ability to engage in clear and accurate information exchange using correct terminology.

Significance of the Study

This study is important for four reasons. First, the study highlights an engaging and motivating learning strategy (MMOG play) that incorporates key elements that theorists agree mediate learning such as experienced-based learning environments, socially-mediated and active learning, and balance between challenge and skill (Egenfeldt-Nielsen, 2007). Second, the study is a response to the convergence of technology-savvy students and sophisticated 21st-Century classroom technologies by demonstrating a strategy (MMOG play) that exploits student capabilities and interests to enhance and deepen learning without the technological limitations of the past such as bandwidth and computer-to-student ratios. Third, it responds to concerns and clarifies misconceptions that educators have expressed about the use of video games as instructional tools. Many educators view new-generation video games (e.g., MMOGs) as solely entertainment vehicles rather than instructional means, whereas, others struggle with the formation of appropriate pedagogical strategies to align video games to academic content standards (Rice, 2007). Fourth, *Serious Game* game developers will gain additional insight on important game components needed in games designed to teach.

Research Questions

1. To what extent do MMOG players use collaborative teamwork strategies?

2. Do students in the MMOG group have higher individual scores on the content knowledge unit assessment of bluebird life cycle and survival needs when compared with traditional instruction?

3. Do students in the MMOG group have higher individual concept-map scores on concept-map construction of bluebird life cycle and survival needs when compared with traditional instruction?

4. Is there a relationship between collaborative teamwork-strategy scores

for students in the MMOG group and posttest scores?

5. Is there a relationship between collaborative teamwork-strategy scores for students in the MMOG group and concept map scores?

6. What is the extent of satisfaction with the MMOG play to present content?

7. What is the extent of satisfaction with the traditional instruction to present content?

Definition of Terms

The following terms are defined for this study. There may be other definitions that apply to these terms, but these are the definitions that are used for this study.

Avatar: The virtual-world, or character, representation of the player in an online game. Avatars in MMOGs developed out of text-based avatars in earlier role-playing games. Players within virtual spaces (worlds) choose customizable images or figures to represent themselves. Players have the ability to choose such features as ethnicity, gender, face, skin tone, and hair and eye color. Avatars can appear exceptionally realistic in higher-quality 3-dimensional MMOGs and based on the game genre can have human or fantasy. Because players are known by avatars, communication is anonymous within the game environment and players are speaking as their character rather than their personal identity (Chan & Vorderer, 2006).

Collaborative Problem Solving: problem-solving activities that involve interactions among a group of individuals (Zhang, 1998).

Collaborative Teamwork Processes: The six elements of the CRESST collaborative teamwork process model that will be investigated in the proposed study are (a) adaptability, (b) coordination, (c) interpersonal, (d) decision making, (e) leadership, and (f) communication. *Adaptability* refers to a group's ability to identify and respond to problems appropriately. *Coordination* occurs when a group's resources, activities, and responses are organized in such a way that tasks are completed on time. *Decision Making* is a group's ability to make use of all available information and to make decisions accordingly. *Interpersonal* refers to a group's use of cooperative behavior in interacting with members of the team. *Leadership* is demonstrated when members of the group provide direction for the team by planning and organizing, distributing tasks, and evaluating group performance. *Communication* is a group's ability to engage in clear and accurate information exchange using correct terminology (Chung & O'Neil, 1997).

Concept Map: Also referred to as *knowledge maps*, concept maps are graphical representations of a concept with terms and links to show interrelationships, is an example of a task designed to measure content understanding. Concept maps consist of nodes, links, linking phrases, and propositions. Nodes represent concepts, and links are connecting lines; linking phrases are words or phrases that indicate the relationships between nodes. Propositions are combinations of two nodes joined by a link and linking phrases. Concept maps are often used as learning tools because they serve as study guides, knowledge integration tools, planning tools, and a tool for assessing what learners know (Jonassen, 2000). Most of the research on concept mapping concentrated on the use of concept maps as social-thinking tools (Bosung, Chia-chi, & I-Chun, 2005).

Digital Game-based Learning (DGBL): Any marriage of educational content and computer games or more specifically; *any* learning game on a computer or online. Digital game-based learning is targeted to meet learning goals in the business, government, military, and education sectors. Through well-designed content and context, Digital

Game-based Learning should incorporate a high-quality learning experience that looks and feels like a video game and computer game all the way through (Prensky, 2000).

Digital Natives: A term describing today's students kindergarten through college who have grown up with new, digital, technologies and communication tools such as Internet, video games, ipods, instant messaging, blogs, cell phones, computers, and MySpace®. A high percentage of digital natives play video games, initiating a call by scholars, researchers, and popular press to investigate how video games that are congruent with how today's learners learn, might be integrated into instructional programs (Prensky, 2006a, 2006b).

Immersive World: Also referred to as microworlds, immersive worlds are given domains or environments that include artifacts and objects that learners can explore in an open-ended, nonlinear fashion (Freitas, 2006).

Massively Multiplayer Online Game (MMOG): MMOGs provide a 3-dimensional synthetic virtual world for hundreds or thousands of players to play and interact simultaneously moving through levels of play and completion of varied tasks. Players engage in avatar-mediated communication throughout game play. MMOGs derived from text-based Multiuser dungeons (MUDs), virtual, interactive worlds where players completed quests and tasks. The following acronyms and labels also refer to MMOGs: MMO (massively multiplayer/multiuser online), MMOPW (massively multiplayer online persistent world), and MMORPG (massively multiplayer online role-playing game; (Chan & Vorderer, 2006). There are a variety of genres associated with MMOGs including fantasy, action, adventure, fighting, puzzle, role playing, simulation, sports, and strategy.

New-generation Games: Educational games that are constructivist-based with a strong emphasis on the learner (an understanding of the schemas that learners bring to a learning experience and providing appropriate scaffolds based on cognitive abilities). These games incorporate artifacts for exploration that mirror real-world experiences, include problem solving situated within a social context, and are focused on learner engagement as a vehicle to learn content. The games provide rich and compelling experiences that are explored further with a variety of teaching methods (Egenfeldt-Nielsen, 2007).

Persistent World: Also referred to as a *Multi-user Virtual Environment* (MUVE), a design quality within MMOGS in which avatars and the world in which they inhabit persist 24 hours a day and 7 days per week. The persistence is dynamic within the virtual world. If a player stops playing at any point, the world continues to change and develop and other players continue to explore and interact. When a player resumes play, they continue where they last left off. Avatar representation is persistent because individuals are able to maintain stable representation of their chosen personality. Persistent worlds and avatars are technologically possible by storing the virtual world and player-character information on one or more servers that are accessed by users from multiple geographic regions around the world (Bowman et al., 2004; Chan & Vorderer, 2006).

Problem Solving: A cognitive process directed at achieving a goal when a solution method is not obvious to the problem solver (Mayer & Wittrock, 1996)

Problem-Solving Strategies: Problem-solving strategies are the intellectual tactics used to solve problems (Chuang et al., 2003; O'Neil & Schacter, 1997). These strategies are domain dependent, defined as strategies associated with a particular subject area or domain independent indicating a strategy that can be utilized across multiple subjects. The design of a simulation in order to infer information or the creation of analogies to understand abstract concepts and the construction of concept maps are examples of domain-independent problem-solving strategies. An information-seeking, problem-solving strategy employed to assist a learner in finding a solution to a particular problem is an example of a domain-dependent problem-solving strategy. According to O'Neil and Schacter , content understanding and problem-solving strategies are best assessed domain-dependently, whereas metacognition and motivation are better assessed domain-independently.

Serious Game: Games and simulations designed to support formal educational and training objectives and outcomes. Serious-game development is a partnership of game designers and education scholars (Freitas, 2006).

Simulation: A reality-based opportunity for individuals to interact with a replication of a social or physical element in reality (Ahlers, Driskell, & Garris, 2002; Black et al., 2007). This study focuses on electronic simulations. A representation of some real-world system that also can take on some aspects of reality for participants or users. Key features of simulations are that they represent real-world systems, they contain rules and strategies that allow flexible and variable simulation activity to evolve, and the cost of error for participants is low, protecting them from the more severe consequences of mistakes.

Situated Learning: Situated learning theory suggests that knowledge acquisition is a dynamic process where learning is *situated* within the culture and context in which it occurs (Lave & Wenger, 1991; Wenger, 1998). Situated learning contrasts with traditional modes of classroom-learning activities characterized by the delivery of abstract concepts taught in isolation (Brown et al., 1989). Brown et al. asserted that no meaningful learning occurs unless it is embedded within the physical and social context within which it will be used.

Video Game: Simple or complex, 2-dimensional and 3-dimensional games played on game platforms (e.g., Sony Playstation) and computers (Gee, 2003). For the purpose of this study, the term video game will be used interchangeably with the term *computer game*. MMOGs are complex video games.

Summary

Presented in chapter one were data on the exponential growth of the video game and *Serious Game* subgroup industries. In addition, an overview from popular press literature and scholarly articles on the potential educative benefits of video games and the limited empirical evidence that has been generated on the benefit of the instructional use of video games, specifically MMOGs to support learning, was presented. The characteristics of MMOGs presented in chapter one appear to provide learning experiences that learning theorists suggest are conducive to learning, meet the needs of today's learners, and provide the physical and social context within which knowledge and skills will be used. The research questions in this study will add to the body of research on achievement gains expected through collaborative MMOG play and student satisfaction with the MMOG play experience.

Subsequent chapters in this study are the literature review, methodology, results, and the summary and conclusions.

CHAPTER

II. REVIEW OF THE LITERATURE

This study is concerned with the effect of collaborative problem-solving strategies in an interactive massively multiplayer online game (MMOG) on individual student achievement. The relevant review of literature is presented in four sections: first, research on situated learning theory (situated cognition theory) and its applicability to computer-mediated instruction and problem-solving; second, research on computer-mediated problem solving; third, the use of concept maps (also referred to as knowledge maps) to assess content understanding; fourth, the Center for Research on Evaluation, Standards, and Student Testing (CRESST) model of computer-mediated collaborative teamwork processes; and fifth, latest findings on the impact of digital game-based learning, including (a) new-generation computer, console, and handheld games (b), MMOGs, and (c) compute-based simulations.

Situated Learning

Several research studies in the field of education support the proposition that the situated-learning model of instruction results in positive student learning outcomes (Farruggia, Gieselman, & Stark, 2000; Griffin, 1995; Griffin & Griffin, 1996; Hendricks, 2001; Herrington & Oliver, 1999, 2000; Liu & Pedersen, 2003).

Previous studies purport computer-based situated-learning classroom experiences utilizing older-generation technology advance student learning (Cognition and Technology Group at Vanderbilt [CTVG], 1990, 1993; Farruggia et al., 2000; Herrington & Oliver, 1999, 2000). As part of a larger, more complex and comprehensive research study focusing on various aspects of the situated-learning model, Herrington and Oliver conducted two qualitative studies that provided situated-learning context through a multimedia program.

In the first study, Herrington and Oliver (1999) used a single-group study to examine preservice teachers' use of higher-order thinking as they accessed the resources of a multimedia program that contained assessment strategies for kindergarten to 12th-grade mathematics teachers and incorporated critical elements of situated learning. Four groups of 2 preservice teachers were given the authentic task of preparing a new assessment plan for mathematics. No information was provided as to whether participants were assigned randomly to groups or whether they chose groups. Each pair was given access to over 60 video clips and electronic text documents about mathematics assessment. These resources provided expert opinions, information that represented multiple perspectives, and coaching and mentoring resources in the form of suggested methods and strategies, all elements of situated learning.

A content analysis of the discourse (each group was videotaped over 2 weeks during the semester) between participants was conducted to investigate participant's use of higher-order thinking. Six *a priori* categories were established to provide a framework to analyze the discourse: uncertainty, deciding on a path of action, judgment and interpretation, multiple perspectives, imposing meaning, and self-regulation of thinking. An analysis of the types of talk employed indicated that each group used higher-order thinking the majority of the time and was relatively consistent across groups (Group 1= 70%; Group 2= 70%; Group 3= 71%; Group 4= 68%) as determined by the "types of talk" employed, although there was considerable disparity between the groups in the types of higher-order talk that was utilized. A question to consider is whether participant knowledge of the videotaping may have caused participants to attend more carefully to the task and thus engage in more higher-level discourse. In addition, although each group used high-level talk as they completed the authentic task, the study failed to provide measures on performance of the authentic task. Did groups design a new assessment plan for mathematics? What were the criteria for success, and to what standard did each group perform? In the current students were assessed on two achievement measures to assess the individual benefits of collaborative dialog.

In the second study, Herrington and Oliver (2000) investigated preservice teachers' responses to a multimedia-learning environment based on a situated-learning model. Participants were 8 second-year preservice mathematics teachers enrolled in a university program who formed groups of 2 of their choice to complete the task (5 hours provided over 2 weeks) of preparing a report to staff (peers in the class) on assessment strategies by utilizing the multimedia resources. The lecturer who introduced the multimedia program to the preservice teachers was also one of the instructional designers of the multimedia content. As student pairs completed the situated task, the lecturer provided assistance to the students as needed. In the third week, each pair presented reports to the staff that were evaluated based upon set criteria. Performance data on the reports of each pair were not provided in the research study. To further expand and merge information gained through participant observation, a follow-up 40-question interview (45 to 60 minutes each) was used to ascertain opinions and feelings of the 8 participants about the situated-learning environment with specific attention given to critical situated-learning elements. Results indicated positive reflective comments from participants in each of the nine elements identified by the researcher.

The results of Herrington and Oliver's (1999, 2000) studies suggest that virtual environments such as those anchored in video or multimedia can provide situated-learning experiences with positive learning outcomes; however, no information was provided on performance outcomes as a result of situated learning. This line of research was further explored in the current research study as the use of an MMOG to create a situated context was investigated. Performance outcomes were measured and comparisons groups were utilized.

Conflicting findings also have resulted from studies comparing situated-learning models to conventional instruction. Hendrick's (2001) conducted a study of 220 seventh-grade students. Half of the students in 5 different class periods received 4 days of instruction for 50 minutes per day on the topic of *causality* using a conventional model (definition of terms, lecture, practice in examining research studies) and the other half from 5 additional class periods for the same amount of time received a situated-instructional model (discussion, modeling, coaching, and examination of actual research studies). The situated-learning instruction group outperformed the conventional-learning group on all posttest measures. Statistically significant differences ($d= .7$ across all class periods) were found for posttests administered immediately following instruction. There was no difference between the two groups on the transfer task administered 2 weeks after instruction.

Griffin and Griffin (1996) conducted a study comparing conventional instructional models and situated-learning models by evaluating the map reading and *wayfinding* abilities of 45 fourth-grade students from two intact classes in a laboratory school. One group ($n=23$) was taught map skills within a situated-learning environment (practice of map skills was done through physically walking through university buildings) while the comparison group (n=22) practiced map skills through conventional methods (guided instruction and written practice exercises). Instructional time for the experimental group and comparison group was limited to 2 hours, one hour on 2 consecutive days for the comparison group and one hour on 2 days with a day in between of no instruction for the experimental group.

Written measures (paper-and-pencil assessment) were administered 4 days after instruction and performance measures (paralleling the situated instruction by physically walking a route) were administered 6 days after instruction. Each measure was repeated after 5 months with a slight variation in the performance task to reduce the likelihood that students were performing the tasks based on memory.

The conventional-instruction group outperformed the situated-learning group on all posttest measures; however, the results indicated no statistical difference between the treatment group (M=77.59) and the comparison group (M=79.86) for the immediate (6 days after instruction) performance assessment and the delayed (5 months after instruction) written assessment (treatment, M=18.25; comparison, M=18.76). Statistically significant results were found between the treatment and comparison groups on the immediate written assessment (comparison, M=17.32; treatment, 15.14) and delayed performance assessment (comparison, M=80.26; treatment, 76.48) with the comparison group outperforming the treatment group. Griffin and Griffin (1996) indicated that the unexpected outperformance of the situated-learning group by the conventional group may have been due to several factors: students in the comparison group were able to work in pairs during practice activities, indoor wayfinding may have been too confining with landmarks that lacked sufficient distinctions of outdoor landmarks, brief (2 hours) situated-learning instructional time, and needed instructional support through the use of multimedia instruction such as videodisks. This researcher concurs with the point that the brief situated instruction was insufficient to establish expert modeling and situated mentoring through practice, critical components of the situated-learning model (Brown, Collins, & Duguid, 1989).

The conflicting findings of Griffin and Griffin's (1996) and Hendrick's (2001) grade-school studies possibly can be explained by the procedures related to each study. In Hendrick's study, the conventional and situated instruction was scripted ensuring standard conditions, instructors received 5 hours of training on how to utilize the lesson plans for each setting, student instruction time on *causality* was 50 minutes for 4 days, and the expert modeling and situated mentoring was robust. Conversely, in Griffin and Griffin's (1996) study, the instruction was unscripted and student tasks within the instructional period were complex and confounded by the brief instruction time. Furthermore, instruction was not supported by robust expert modeling and situated mentoring. Research on the benefits of computer-mediated modeling and scripted collaboration (components of cognitive apprenticeship) to support problem solving also has been conducted.

In a study of 36 dyads (two individuals - one advanced psychology student and one advanced medical student in each dyad), Rummel and Spada (2005) compared four conditions on achieving a collaborative problem solving task: (a) learning from observing a worked-out example of effective computer-mediated collaboration (model condition), (b) learning from scripted computer-mediated collaborative problem solving (script condition), (c) learning from unscripted collaborative problem solving (unscripted condition), and (d) comparison group with no learning phase. Nine dyads were assigned randomly to each condition, and each participant within the dyad was assessed to have the same level of expertise in terms of technical, domain knowledge, and experience in working collaboratively. The problem-solving task required each dyad to interact through a computer-mediated environment (desktop conferencing) to review the case of a fictional patient and to make collaboratively an appropriate diagnosis and treatment plan using their combined expertise based upon the patient's medical and psychological pathology. Each dyad within the model (scripted and unscripted conditions) participated in a learning and application phase. Dyads in the comparison condition only participated in the application phase. Prior technical, domain knowledge (each participant's medical and psychological content knowledge), and experience in working collaboratively was assessed. The members of each dyad worked from separate rooms but had audio and video connections to support synchronous video and audio communication. Each member also had a shared text editor for the editing of collaborative solutions and a personal text editor for note taking.

During the learning phase, dyads in the model condition (observation of a worked-out example) observed exemplary collaborative problem solving by listening to an audio recording of a psychology and medical student and by watching animations of the joint solutions designed within the collaborative text editors. The dyads observed the formulation of the problem, a description of the solution steps, and the solution itself from the model collaboration. To deepen learning, the researchers embedded on-screen instructional explanations and practice activities into the model collaboration. During the learning phase of the scripted condition (scripted collaborative problem solving), dyads were given a detailed paper-based script that outlined specific interaction phases and the type of dialog that was required between partners. The structure of the scripted condition was equivalent to the model condition in that the collaborative phases outlined in the model condition were the same in the scripted condition. During the learning phase of the unscripted condition (unscripted collaborative problem solving), dyads engaged in problem solving without any guidance. In the control condition, dyads did not have a learning phase but did participate in the application phase. The dyads in each condition participated in the experimental session for 6 hours with a 24-hour period between the learning and application phases.

Dependent variables for the study were the collaborative process (analysis of logfiles for activity patterns and analysis of the dialog of the 36 dyads as compared with the exemplary collaborative model and script condition), the joint solution (assessed against a solution by medical and psychological experts), and the performance on an individual knowledge posttest (knowledge about central aspects of good collaboration and knowledge about important elements of a good therapy plan).

The collaborative process (analysis of logfiles) was based on a comparison of time spent on individual work (believed to be critically important in problem solving requiring complementary expertise) in the exemplary model and script condition and the time spent in the four conditions above. The instructional guidance provided in the exemplary model and script condition was 57 minutes for individual work and 63 minutes for joint work. These comparisons were made by computing the difference between data from the four conditions and data from the exemplary model for the amount of individual work. Interaction between partners was analyzed by evaluating coordinative (e.g., time management, work coordination) and communicative dialog (e.g., feedback, explaining content).

Results for the collaborative process was statistically significant (Eta squared = .24, a very large effect). For all conditions, less time was spent in individual work than in the exemplary collaborative model (57 minutes of individual work); however, dyads in the model condition (M= 53 minutes of individual work) outperformed dyads in the scripted (M=44.56 minutes of individual work), unscripted (M= 39.11 minutes of individual work), and comparison (M=40.67) conditions. Results for the analysis of dialog was also statistically significant (Eta squared = .27, a very large effect) for the content-related division of labor dyad dialog with the number of minutes of dialog about division of labor content for the model, script, unscripted, and comparison conditions M=12.89, M=13.56, M=8.00, and M=15.33, respectively. Results for the quality of the joint solution was also statistically significant (Eta squared = .32 for the *diagnosis* subscale and .25 for the *therapy* subscale, both are large effects). Results for the diagnosis subscale indicated that dyads in the model condition (M= 8.89) outperformed dyads in the script (M= 4.39), unscripted (M= 6.50), and comparison conditions (M= 6.28). Results for the therapy subscale indicated that dyads in the script condition (M= 18.67) outperformed dyads in the model (M= 14.44), unscripted (M= 12.61), and control conditions (M= 11.67). Results for the posttest was also statistically significant (Eta squared = .24 for *knowledge about central aspects of good collaboration* subscale and .39 for the *knowledge about important elements of a therapy plan* subscale, both are large effects). Results for the *knowledge about central aspects of good collaboration* subscale indicated that dyads in the model condition (M= 3.14) outperformed dyads in the script (M= 3.06), unscripted (M= 2.33), and control conditions (M= 1.67). Results for the *knowledge about important elements of a therapy plan* subscale indicated that dyads in the script condition (M= 4.11) outperformed dyads in the model (M= 4.06), unscripted (M= 2.31), and comparison conditions (M= 1.94).

Outcomes from this study indicate that the problem-solving outcomes from the instructional conditions (model condition and the scripted condition) were superior to those of the unscripted and control conditions. Based on these findings, in the current study, the researcher incorporated a worked-out example of effective collaborative interaction within a MMOG. Participants observed a worked-out example that incorporated possible messages to enhance collaborative interaction before engaging in game play. The messages were similar to those in the scripted condition in the above study; however because of Rummel and Spada's (2005) contention that scripted conditions may impact negatively learner motivation, in the proposed study, the researcher also encouraged original messages among players as participants engage in game play to mediate possible negative motivational impact.

In a study of 66 sixth graders from three intact classes (one class of 20 students, one class of 22 students, one class of 24 students), Liu and Pedersen (2003) compared three conditions (expert modeling also referred to as cognitive apprenticeship, didactic, and help) for the transfer of strategies from a problem-based learning (PBL) unit to an analogous problem situation. The computer-based program utilized in the PBL unit was *Alien Rescue*, a simulation that places students in the role of novice scientists aboard an international space station. The young *scientists* were tasked with rescuing alien life forms by recommending worlds within the solar system that would serve as suitable homes for the displaced aliens. The *scientists* were required to provide a rationale for the worlds they recommended based on information gathered through the design and launching of probes and by searching existing databases.

To support student learning, a multimedia-based tool provided video segments of an expert engaged in the same tasks as students in the PBL activity using a expert modeling, didactic, or help strategy. Students viewed these video segments during preidentified junctures of the problem-solving activity. In the expert-modeling condition, the expert modeled the tool functionalities within the simulated environment and his cognitive processes during problem solving. In the didactic condition, the expert explained tool functionality and offered guidelines and suggestions for solving the problem rather than modeling the strategies. In the help condition, the expert explained tool functionality outside of the context of the problem-solving tasks that students were expected to solve. No advice was provided to students as to how to approach their work in the help condition.

A paper-based instrument was administered to students to measure problem solving with a novel problem (choosing the right habitat for a salamander) after completion of *Alien Rescue*. The first part of the instrument evaluated the types of questions that students generated to solve the problem. There were 21 possible appropriate questions. Scores were calculated by dividing the number of appropriate questions that a student generated by the total number of questions that each student generated. High scores indicated students' understanding of the type of questions needed to solve the problem. The second part of the instrument asked students to write a rationale for the salamander habitat that they chose. There was no one correct answer as to the habitat but rather a rubric (scores could range from 0 to 12 points) was used to evaluate students' rationale for choosing a particular habitat.

A one-way Analysis of Variance (ANOVA) was used to analyze scores for both parts of the measure. Results from the first part of the measure demonstrated that students in the expert-modeling groups generated more appropriate questions to solve the problem-solving tasks than the didactic and help groups. A statistically significant difference was found between the expert modeling and the help groups. There was no statistical significance found between the expert modeling and the didactic groups; however, there was a moderate to large effect size (d= .69) reflecting a difference in the means. There was no statistically significant difference between the didactic and the help groups. In the second part of the measure (rubric score for generating a cohesive rationale), the expert- modeling group outperformed the didactic and help groups. Statistical significance was achieved with a very large effect size (d= 1.51) between the expert-modeling group and the didactic group. An equally very large effect size (d= 1.14) was found between the expert-modeling group and the help group. The aforementioned research that focuses on expert modeling (cognitive apprenticeship) underscores the contention that complex problem solving is a key outcome in the situated model. In addition, it underscores the instructional benefits of utilizing simulated environments to enhance problem solving, such as the MMOG that will be used in the present study. For the purposes of the proposed study, it is necessary to define how the construct *problem solving* will be used in the proposed research study.

Although few studies exist that use the CRESST problem-solving model as the theoretical basis, researchers have conducted studies on the effect of collaborative, computer-mediated problem solving on learning.

Computer-mediated Problem Solving

The literature on collaborative problem solving suggests that collaboration produces positive academic outcomes when learning opportunities incorporate modeling of problem-solving behaviors, provide explicit instruction in problem-solving strategies, high-quality discourse, and feedback on the problem-solving process (Koch, Kumpe, & Zumbach, 2004; Liu & Pedersen, 2003; Rummel & Spada, 2005). Furthermore, research suggests that collaborative problem solving can be more effective than individual problem solving because problem-solving activities are not limited to the cognitive properties that each individual brings but can rise to higher-level combined cognitive properties through group interactions that produce more resources, shared and distributed task and memory load, and cross-checking of errors (Barron, 2000; Damon & Phelps, 1989; Koch et al.; Liu & Pedersen; Webb, 1993).

Barron (2000) conducted a study where high-performing sixth-grade students engaged in complex, narrative-based mathematics problem solving utilizing video-based instruction by solving a problem with as many as 13 embedded subproblems. In the first phase of the study, 96 students were assigned randomly to work in collaborative triads (16 groups of 3) or alone to solve a multistep problem. In the second phase of the study, the 96 participants completed the same multistep problem working alone regardless of the condition that they had previously been assigned. In the third phase of the study, each of the 96 participants completed an analogous multistep problem working alone. To assess problem solving, researchers examined participant responses to eight questions (two general planning questions to assess ability to generate subproblems, three subproblem planning questions to assess students' quantitative reasoning in identifying quantities they would need to know to respond to the subproblems, and three solutions questions to calculate answers to the subproblems).

The collaborative groups outperformed individuals in all three levels of the first phase of the study (General planning group, M=.48, General planning individual, M=.32, d=1.19; Subproblem planning group, M=.70, Subproblem planning individual, M=.58, d=.67; Solutions planning group, M=.77, Solutions individual, M=.60, d=.65) the results of which were statistically significant with effect sizes that ranged from moderate to strong. The second and third phases of the study were analyzed with repeated measure ANOVA based on condition (initial group problem solving or initial individual problem solving). In the second and third phase of the study, completing the same multistep problem individually and completing an analogous multi-step problem, respectively, results indicated that students in the team condition outperformed (phase 2: general planning, M=.47; subproblem planning, M=.76; solutions, M=.79; phase 3: general planning, M=.46; subproblem planning, M=.73; solutions, M=.79) students who worked individually (phase 2: general planning, M=.40; subproblem planning, M=.70; solutions, M=.66; phase 3: general planning, M=.42; subproblem planning, M=.69; solutions, M=.69) The results of this study suggest that collaborative work produces superior outcomes than individual work; however, as Barron (2000) indicated, it does not provide information on the specific collaborative interactive components that led to the superior performance. In the current study, student collaboration during game play assisted students in being able to play the game successfully such as in the aforementioned study. An additional focus in the current study was to review the interactive components of computer-mediated instruction that enhance individual achievement outcomes.

In a study of 180 first- and second-grade students, Hogan, Tudge, and Winterhoff (1996) conducted an experiment to assess the impact of feedback and partner collaboration in solving a mathematical task. Each student worked alone or with a partner who was less, equally, or more competent (based on pretest scores) to devise a rule (seven rules total) for predicting the movement of a balance beam. Only students who used rules 2 to 4 at the time of the pretest qualified as the study targets. Two-thirds of students were chosen randomly to receive feedback during the treatment (supports were removed under beams so that students could determine whether their predictions were correct), and one-third did not. The balance beam had eight removable sticks spaced an equal distance from the fulcrum. During the treatment phase, differing numbers of weights (metal nuts) were fitted over the sticks at varying distances from the fulcrum for a total of 14 unique problem configurations. For the pretest and two posttest measures (two posttests were used to determine the stability of changes between both posttests), the configurations were presented on paper with the position of the weights clearly marked. Students were required to mark boxes on the left, middle, or right indicating whether the beam would stay balanced or tip to the right or left. Individual students or dyads (same rule partners, less competent partners, more competent partners) predicted the movement of the balance beam based on seven researcher pre-identified rules ranging from guessing to reasoned explanations.

The results of a multivariate analysis of variance (MANOVA) revealed statistical significance across all conditions (individuals, same rule partners, less competent partners, more competent partners) in the pretest, posttest 1, and posttest 2 measures (M = 2.87, M = 3.89, M = 3.64, respectively) with time (pretest, posttest 1, and posttest 2) as a main effect. Statistical significance also was found between the pretest and the initial posttest across all conditions when feedback was provided (combined pretest M = 3.09; combined posttest 1 M= 4.36). Unexpected results of univariate tests indicated that students working alone (pretest M = 2.87) who received feedback showed a statistically significant level of improvement over the partner groups (pretest M = 3.18) on the two posttest measures (posttest 1 M = 4.67, posttest 2 M = 4.73; posttest 1 M = 4.24, posttest 2 M = 3.92, respectively). By contrast, results for students working with a partner with no feedback showed marked but no statistically significant improvement from the pretest to the second posttest (pretest M = 2.5, posttest, M = 3.20, respectively). Students working alone with no feedback (pretest M = 2.30) actually declined below the pretest measure on the second posttest (M = 1.80). The difference in the amount of change from the pretest between students working alone and students working in pairs at the second posttest was statistically significant. Hogan et al.'s (1996) results suggest that collaborative groups do not always produce superior academic outcomes and that particular conditions are necessary to increase the probability as indicated in other studies. Another concentration of the current study was to investigate how a MMOG that has embedded feedback and played collaboratively problem solving impacts individual achievement.

In a study of 163 (39 groups of 4 to 5 students) linguistically, ethnically, and racially diverse sixth-grade students from five classrooms in a school located in

California's Central Valley, Abram, Cohen, Lotan, Scarloss, and Schultz (2002) investigated the impact of providing specific guidelines (evaluation criteria) on the characteristics of exemplary collaborative work and work products by analyzing group discussions (measured by evaluative product-focused, content-related, and off-task group talk), group products (measured by three separate rubrics assessing concrete content, conceptual content, and presentation conventions), and written assignments (assessed on facts and details, the big idea, organization, and mechanics aggregated to the group level). Each teacher from the 5 classrooms were trained to use complex instruction strategies (teaching at high intellectual levels within a diverse (academically and linguistically) to create equitable classrooms. Curricular materials used in complex instruction include nontext resources (pictures, diagrams, music), allow diverse students to make varied intellectual contributions, and incorporate challenging group activities. Each group rotated through a variety of well-designed group tasks each day that required products that demonstrated conceptual understanding and factual information related to the academic content. Three teachers in the experimental classrooms integrated skill-building activities that outlined collaborative evaluation criteria and allowed students to *practice* these skills. In the nonexperimental classrooms, teachers integrated general skill-building activities designed to improve the quality of group discussion. To derive measures of group talk, student groups were audiotaped as they attempted five tasks across 5 days related to Ancient Egypt social-studies concepts to evaluate to what degree students were engaged in evaluative (questions, declarative statements, opinions, or reflections about the product or presentation), product-focused (comments about the quality of the group's product), and content-related talk (talk that explicitly addresses the given task). Only three of the five audiotapes were analyzed. The researchers scored the group presentations and products by using two developmental rubrics (concrete and conceptual content with scores ranging from 1, indicating minimal or missing information to 4, indicating applied with included reasoning, coherent, and exemplary) and one task specific rubric on the presentation conventions (each aesthetic convention received a 0 to 2 score). Scores ranging from 1 to 4 were assigned to each of the four areas (Facts and Details, Big Idea, Organization, and Mechanics) of the final individual essay.

In terms of group talk, results from t tests of the difference of means between the group that received evaluative criteria and the group that did not showed statistically significant differences in the percent of evaluative product-focused group talk used (2.8% and 1.7%, respectively) and off-task talk (12.7% and 19.5%, respectively). No statistically significant differences were found between groups on talk related to the group product. Results showed statistically significant differences on group products as well as the final essays with the groups that received evaluative criteria outperforming performing those who did not (group products, M = 2.5 and M = 1.8; essay, M = 3.9 and M = 3.1, respectively).

In another study examining group talk and problem-solving capacity, Hoek and Seegers (2005) investigated how student's verbal interactions developed while working on ill-structured mathematics problems in small, collaborative group while receiving guidance and modeling of collaborative problem-solving skills from teachers. Participants in the year-long study of 46 vocational technical education high-school students were from two different classes in the Netherlands. An examination of student parallel work (no collaborative activities take place in group), guided work (one student takes a leading role and others follow critically), disputational talk (one or two participants dominate the group process), cumulative talk (emphasis is on agreement and participants accept other's contributions without critical reflection), and exploratory talk (participants collaborate actively, have equal contributions, and are willing to evaluate contributions critically) in a year-long analysis of videotaped group sessions was conducted to ascertain growth in verbatim verbal interactions during open-ended mathematics problem solving.

In each of the two classrooms, teachers modeled collaborative and exploratory (answering questioners with group questions, posing questions to stimulate self-correction and reflection, and feedback on how students worked collaboratively) problem solving and served as coaches by stimulating whole-class discussions and offering feedback on student understanding of mathematical concepts. Throughout the study, teachers envisioned how mathematical activities would evolve then adapted their instructional activities consistently based upon classroom experiences and events, an iterative process referred to in the study as a design experiment. In groups of four, student groups worked on authentic activities that integrated mathematics, physics, and information technology. The assigned mathematics problems were sequential and incorporated common mathematics concepts.

In each of the two classrooms (Class A and Class B) of participants, one group of four students was videotaped during an entire mathematics lesson every 2 weeks for the duration of the school year. Classification of student work, talk, or both (parallel or guided work and disputational, cumulative, or exploratory talk) referred to as episodes served as the unit of analysis. An episode started when specific problems or questions related to the mathematics activity arose and ended when students reached agreement or when an interruption (e.g., task irrelevant comments) occurred. Within this classification theme, exploratory talk had the highest impact on problem-solving capacity and subsequent enhanced knowledge construction skills because of the following characteristics: engagement in frequent reasoning, interrogative and evaluative exchanges, equal distribution of role-taking (at various points different learners initiate and lead discussions) and effort (equal distribution of effort among learners), and a high level of collaboration. Many of these characteristics are evident in MMOG play, the focus of the current study.

The results of the stimulation of thinking about mathematical concepts and ideas and the modeling of exploratory problem solving by teachers produced positive results. In Class A, frequency data indicate that the percentage of exploratory talk increased from 16% at the beginning of the year to 66% by the end of the year. Similar results were found in Class B with the percentage of exploratory talk increasing from 21% at the beginning of the school year to 74% at the end of the school year. The total number of episodes evaluated was not provided and no posttest measures were administered to ascertain cognitive outcomes of exploratory talk. In both of the previous studies, the researchers conclude that the type of interaction that students have during collaborative activities impact student achievement. Although a distinct approach was used to examine the types of interactions that lead to successful problem solving in the current study, these studies reinforce the need to analyze carefully these interactions to improve group and individual problem solving.

In a study of 188 undergraduate students, Ohtsubo (2005) investigated the relationship between redundancy in task assignments and group problem-solving performance. In the study, members of dyads and triads received shared information (each member received all seven clues to memorize) or unshared information (each member received a portion of the seven clues to memorize) to solve a logic puzzle. The results of a pilot study indicated that participants would be able to memorize three clues but unable to memorize four. Providing task clues to all group members in dyads and triads or providing a portion (four clues) to dyads and triads caused cognitive overload in the pilot study; therefore, in Ohtsubo's study the proposed hypothesis was that shared and unshared dyads as well as shared triads would not perform as well as unshared triads. The 188 participants (19 triads in each of a shared and unshared condition; 19 dyads in the shared condition; 18 dyads in the unshared condition) were enrolled in an undergraduate organizational psychology class. Based upon the condition assigned, each participant was given one minute to examine and memorize the logic-puzzle clues and groups were given 20 minutes to solve the puzzle. Individual participants also were given a memory test of all the clues after completing the group problem-solving task.

Frequency results indicated that unshared groups (dyads: 17% - 3 groups; triads: 66% - 12 groups) outperformed the shared groups (dyads: 11% - 2 groups; triads: 17% - 3 groups) in returning the correct solution, and, as hypothesized, groups in the unshared triad condition outperformed all groups. In the current study, it was expected that through the hints that individual players receive during MMOG play that an unshared condition (each player receives different hints based upon where they are in the game) is created, and through collaborative problem solving, players share what they know to support the game play of other players.

Concept Maps

A concept map is a graphical tool designed to organize and represent knowledge (Abrams, Canady, Gasper, & Stoddart, 2000; Adesope & Nesbit, 2006; Canas & Novak, 2006; Clariana & Taricani, 2006; Jonassen, 2000; Mayer & Stull, 2007; Novak, 1998; Rubba & Rye, 1998). Rubba and Rye described concept maps as metacognitive tools that externally represent via a visual image a student's conceptual understandings. The components of concept maps (also referred to as knowledge maps) are concepts (key terms) and links to show interrelationships between concepts. Concept maps include nodes, links, linking phrases, and propositions. Nodes represent concepts, links are connecting lines, and linking phrases are words or phrases that indicate the relationships between nodes. Propositions are combinations of two nodes joined by a link and linking phrases.

Concept maps can be used as learning tools in every domain and at every academic level from elementary through postsecondary. Concept maps are used as learning tools because they serve as study guides, knowledge integration tools, planning tools, and a tool for assessing learner's prior knowledge, gaps in understanding and knowledge growth (Adesope & Nesbit, 2006; Jonassen, 2000; Li, Ruiz-Primo, Schultz, & Shavelson, 2001; Mayer & Stull, 2007; McClure, Sonak, & Suen, 1999; Rubba & Rye, 1998). Concept-map construction to summarize content is a viable approach to assess learning.

Stemming from Novak's (1990) longitudinal research in the 1960s and 1970s on the potential of concept-mapping activities to improve science teaching and learning, interest in this pedagogical approach has continued to develop.

Since 1990, the integration of concept-map tasks to demonstrate and assess science content understanding has accelerated and been utilized widely and effectively as a teaching and learning strategy (Li et al., 2001; Mattern, Schau, Teague, Weber, & Zeilik, 2001; McClure et al., 1999; Novak, 1990; Rubba & Rye, 1998). McClure et al. identify four categories of concept-mapping potential in the science classroom: (a) as a learning strategy, (b) as an instructional strategy, (c) as a strategy for planning instruction, and (d) as a means of assessing student's understanding of science concepts.

As a learning strategy, concept maps capture the structural nature of the learner's knowledge. Student construction of concept maps provides a clear picture of how domain-related science concepts are mentally organized and how relationships between concepts are formed. In the current study, students created concept maps to demonstrate their understanding of an ecology-based science instructional unit that focused on the survival needs of the Eastern Bluebird.

The research literature suggests that learner-generated concept-map tasks are effective approaches for promoting learning although fill-in concept maps (lists of concepts and/or link words are provided to learner to aid in concept-map construction) are also utilized. Mattern et al. (2001) contended that fill-in concept maps are effective measures of learner knowledge structures. Other researchers suggest that fill-in concept maps are not as effective in assessing student's domain knowledge because the knowledge structure is imposed rather than self-generated. This approach can misrepresent what students actually know by providing artificially high scores (Li et al., 2001).

Li et al.'s (2001) research defined high-directed concept maps as maps where the concepts, linking lines, linking words, and map structure are provided by the teacher, whereas, low-directed concept maps are completely learner generated. Li et al. suggest that low-directed concept maps better indicate the proximity of a learner's knowledge structure to that of an expert's knowledge structure. By imposing a structure such as fill-in maps, Li et al. (2001) contended that it is difficult to assess whether students' knowledge is approaching that of experts and showing appropriate relationships between concepts.

Mayer and Stull (2007) described learner-created concept maps based on student understanding of scientific text as a generative process. It is generative because students select and organize information from the text while constructing new information; however, they suggested that the need to do extraneous processing (processing that does not support the construction of knowledge) limits generative processing. Adescope and Nesbit (2006) suggested that learners who are adept in reading and constructing concept maps may be better able to distinguish the relationships among concepts presented in text. Abrams et al. (2000) described an open-ended approach to learner-generated concept-map tasks where learners are given a small number of prompt concepts to utilize with no other limitations.

In the current study, student concept-map tasks used an open-ended learner-generated approach rather than a fill-in approach. Students were provided a limited list of concepts related to bluebird survival and were instructed to add to their maps by generating additional concepts that reflected their understanding of the objectives of the instructional unit.

The use of concept-maps tasks to assess student knowledge has proven to be an effective, although there have been challenges in determining reliable concept-map scoring systems for student-generated maps (Abrams et al., 2000; McClure et al., 1999; Rubba & Rye, 2002). Early scoring mechanisms were structural in nature. Assessment components consisted of the number of concepts, number of links, number of hierarchical levels (most general and inclusive concepts at the top and less specific below), number of cross-links (links between concepts in different segments of the concept map), and the number of specific examples or events that clarified the meaning of a given concept. The focus was on the elaborateness of the map rather than its accuracy or quality. In many cases, the scoring techniques proved to be elaborate as well but could be scored objectively (counting the number of the aforementioned components).

Relational concept maps focus on the accuracy and quality of the concept map. Student concept maps are often measured against a criterion or expert map. Ruiz-Primo and Shavelson (1996) in their review of 21 research studies on the use of concept maps to assess learning, most were relational and employed an expert-referent map. Most of the studies also scored maps based on accuracy and quality rather than simply counting concepts, links, hierarchical levels, and cross-links. Concept maps evaluated by human experts (as opposed to technology-based scoring schemes) using a criterion map have shown a high degree of interrater reliability (Conlon, 2006).

In the current research study, students' knowledge structure of the Eastern Bluebird was assessed through student-generated nonhierarchical concept maps.

Students' concept maps were scored against a collaborative expert concept map constructed by the researcher and a panel of bluebird experts. Maps were scored using a relational approach that assesed accuracy and map quality. Interrater reliability was established by scoring 10 student maps against an expert map utilizing a scoring rubric.

Research on the impact of the use of concept maps to assess content understanding will be discussed later in this review of literature.

In their review of literature on computer-mediated collaborative concept mapping, (Bosung, Chia-chi, & I-Chun, 2005) found that most of the research on concept mapping concentrated on the use of concept maps as social-thinking tools (typically dyads or triads) focusing on the process of concept-map construction or the final concept-map product. Participants' use of collaborative teamwork skills to construct concept maps and their relationship to the quality of the final concept map is an example of a process focus rather than the end product, the approach used in the CRESST studies (discussed below). In addition, most of the research has been completed in laboratory settings that limit the generalizability of the findings. In the proposed study, concept mapping will be used to assess individual content understanding through the construction of individual concept maps rather than collaborative content understanding, a key measure according to other researchers (Adesope & Nesbit, 2006; Gilbert & Greene, 2002; Kommers & Stoyanova, 2002).

In their research on synchronous, asynchronous, and face-to-face co-elaboration of knowledge maps, Basque and Pudelko (2004) conducted a comparative study of 24 dyads of postsecondary students from a variety of disciplines. Each dyad was assigned randomly to a synchronous, asynchronous, or control group (eight dyads per group) to construct collaboratively a concept map of the principal components of Cognitive Information Processing (CIP) immediately after reading a one-page document about CIP. Participant's concept maps were compared with models designed by content experts and were scored based upon the number of knowledge objects or nodes and propositions (two nodes and a link) in the participant's map that were represented in the expert model as well. Researchers also assessed learning of CIP by comparing group teacher-made pretest and posttest scores. Post-hoc analyses indicated that scores were statistically significantly higher for dyads in the control group than in the asynchronous group on the collaborative knowledge-modeling task. There were no statistically significant between-group differences for the knowledge propositions task. Based on analyses of pre- and posttest results, the effect of modality of collaborative knowledge modeling on learning indicated no statistically significant difference between groups, although descriptive statistics showed growth in the mean from pre-to posttest (3.56 to 11.81 in the synchronous group, 3.81 to 9.75 in the asynchronous group, and 5.31 to 10.75 in the control group) for each group of dyads. With a total possible score of 21, posttest scores were relatively low. In the current study, participants constructed individual concept maps after collaborative MMOG play.

Adesope and Nesbit (2006) conducted a meta-analysis reviewing 55 studies in which students in grade levels ranging from fourth grade to postsecondary demonstrated learning by constructing, modifying, or viewing concept maps.

Theorists in Adesope and Nesbit's (2006) meta-analysis hypothesized that the beneficial effects of student-constructed concept maps, such as raised posttest achievement scores (Gallo et al., 1993), enhanced comprehension, and improved selfregulatory behaviors, are due to the intrinsic properties of concept maps or the appeal of concept maps to individual differences. Other studies suggest that the construction of concept maps enhance learning and recall individually and in groups when they are used to summarize information (Adesope & Nesbit, 2006; Moore & Readence, 1984; Wang, 2006 October). The current study investigated participants' recall of science concepts learned about the life cycles, habitats, and survival needs of various animals through MMOG play by the creation of player-made concept maps.

In Bolte's (1999) study, preservice elementary and secondary teachers in two Calculus I, one Survey of Geometries, and one Structure of Math courses constructed individual concept maps and interpretive essays to review or summarize learning following instruction. Holistic combined scores on the concept maps and interpretive essays were compared with individual student performance on traditional measures such as homework and quizzes, hourly tests, final exams, and course grades. Correlations showed no statistically significant difference between the traditional measures and the concept maps and interpretive essays; however, the concept maps and interpretive essays were more highly correlated with the final grade in three of the four classes (Calculus IA, traditional $r=.75$, concept map/essay $r=.86$; Calculus IB, traditional $r=.76$, concept map/essay $r=.88$; Survey of Geometries, traditional $r=.72$, concept map/essay $r=.74$) than the combined quiz and homework scores. In Gallo et al.'s (1993) meta-analysis of 18 studies measuring posttest achievement, mean effect sizes for collaborative concept-map construction was .88, a large effect. Following this line of research, in the current study, participants constructed individually concept maps to summarize what they had learned about science-based concepts.

CRESST Collaborative Problem-Solving

The CRESST team of researchers conducted two studies focused on the examination of collaborative teamwork processes in the context of a group concept-mapping activity using a simulated web environment, the findings of which are applicable to the research design of the proposed study (collaborative problem solving within an online virtual world and individual concept-map construction). In the first study (Chung, Herl, & O'Neil, 1999), participants used 37 predefined messages as the sole means of communication to support collaborative problem solving (teamwork processes) within a computer-mediated environment.

Chung, Herl, et al.'s (1999) study examined the feasibility of utilizing a computer-based networked collaborative concept-mapping system to measure the aforementioned CRESST teamwork-skill components: adaptability, coordination, decision making, interpersonal, leadership, and communication. Team members were middle- and high-school students from 6 classes at 2 U.S. Army bases in Germany. The study was a pretest-posttest design with 7 months between the administrations of the tests. Students were assigned randomly to triads (23 groups, 69 participants for the pretest and 14 groups, 42 participants for the posttest). The task of the triads was to construct a concept map based on the environmental-science content (18 concepts and 7 relational links defined by content experts) from a simulated web environment (200 web pages and 500 images) by anonymously exchanging predefined messages within a computer-based networked environment. The researchers developed the predefined message set from an analysis of 798 messages sent by participants in a previous pilot study. Off-task (messages that did not relate to the construction of concept maps) messages were discarded then a reduced set of messages was defined based on feedback from participants in previous studies including the CRESST pilot and messages designed by the researchers. Two independent raters sorted the messages into the five collaborative teamwork processes: adaptability, coordination, decision making, interpersonal, and leadership. Disagreements between the raters were resolved through discussion. Based upon input from participants jointly constructing concept maps in follow-up in-house usability studies, the set of messages were further defined. The final message set consisted of 37 messages, 35 belonging to the five teamwork-process categories (e.g., *adaptability*; how should we link?; *coordination*; we only have 5 minutes; *leadership*; let's add a link), one "yes" and "no" message, and a final message indicating that a message was sent in error. Within the networked computer environment, participants could send the majority of the messages without typing by clicking on 35 numbered buttons that corresponded with each of the predefined messages. Other predefined messages required minimal point-and-click input. Participants were provided a list of the predefined messages on paper to assist them in clicking the appropriate computer-based buttons.

The researchers computed team outcome measures by comparing team concept maps against expert models, whereas individual-and teamwork-process skills were measured by determining the degree to which individuals and their team engaged in each of the CRESST teamwork-skill components. Results indicated that the mean for the 4 knowledge-mapping posttest measures (semantic content score, M=5.98; organizational structure score, M=0.26; number of terms used, M=15.36; and number of links used, M=22.21) were far lower than the expert models (semantic content score, M=22.50;

organizational structural score, M=0.46; number of concepts, M=18.00; number of links used, M=44.75). Two-tailed t tests on the pretest and posttest outcome measures of the knowledge-mapping task showed a statistically significant difference for the *number of links used* category. Frequency counts for individual and team-level processes indicated that *decision making* was used less frequently (4% of the time) as opposed to a range of 15% to 22% for the other teamwork processes. Statistically significant positive relationships were only found between *coordination* and *decision making* (r=.55) for the pretest and between *adaptability* and *coordination* (r=.49) and *adaptability* and *decision making* (r=.48) for the posttest. No statistically significant positive relationships were found between team-process skills and outcome measures. All correlations were negative suggesting a pattern that the more the triads used predefined messages, the lower they performed on the knowledge-mapping task. The researchers hypothesized that this result was due to the split-attention effect because participants were required to split their attention among three elements of the computer system.

In response to Chung, Dennis, Herl, O'Neil, and Schacter's (1999) findings, Hsieh and O'Neil (2002) conducted a study to investigate the effect of a simulated-web environment on collaborative problem solving. They hypothesized that Chung, Dennis et al.'s unanticipated results (no statistically significant positive relationships found between collaborative-team-process skills and outcome measures) were due to the lack of useful team feedback and because the task was not an authentic group task. Hsieh and O'Neil defined an authentic group task as a task in which no single individual possesses all the resources and no single individual is likely to solve the problem or accomplish the task objectives without at least some input from the others in the group (Cohen &

Arechevala-Vargas, 1987). Hsieh and O'Neil modified the group task so that it was authentic by defining roles for the participants. Each participant was either the leader (responsible for constructing the knowledge map) or the searcher (responsible for conducting the simulated web search and supplying the information to the leader as well as accessing feedback). In this scenario, participants needed input from others to complete the task; therefore, this constituted a true group task. Hsieh and O'Neil's study also examined the impact of two types of feedback on team outcomes that is not a focus of the proposed research; however, collaborative problem solving (teamwork processes) were measured using predefined messages as in Chung, Dennis et al.'s (1999) study.

The subjects of the study were 120 Asian American middle- and high-school students randomly assigned to dyads. One student was assigned randomly to be the leader and the other the searcher. Each dyad was assigned randomly to one of two feedback conditions: knowledge of response feedback (verification as to whether answers are correct or incorrect) or adapted knowledge of response feedback (verification as to whether answers are correct or incorrect as well as customized information regarding improvement from previous access to the feedback). As in the Chung, Dennis et al.'s (1999) study, each dyad's task was to construct a concept map using 18 predefined environmental-science concepts and 7 links. To measure group communication, Hsieh and O'Neil (2002) used 12 of the 35 predefined messages from Chung, Dennis et al.'s study and constructed an additional 25 messages for a total of 37 predefined messages. Messages that were used infrequently in Chung, Dennis et al.'s study were eliminated, and new messages related to unique tasks of information seeking and feedback were added. Each of the messages was categorized into one of the 6 collaborative teamwork processes. The same simulated web interface from Chung, Dennis et al.'s study consisting of 200 pages and 500 images was used.

Group outcome measures were computed by comparing participant's concept maps against the concept maps of four experts. Individual teamwork-process measures were computed by totaling the number of messages sent from individuals in each of the teamwork-process categories, whereas group-level teamwork-process measures were computed by totaling the amount of messages that individuals in each group sent from each of the teamwork-process categories. Information-seeking behavior (problem-solving strategies) that was defined as browsing and searching through the environmental-science content and as requesting and responding to feedback was measured by the participant's selection of web pages and hypertext links that were clicked as well as the complexity of search queries and feedback inquiries. The entire study was completed in 56 minutes, 36 minutes for dyads to construct the concept map, 5 minutes for an introduction to the study, and 15 minutes for training of the computer interface.

Results of Hsieh and O'Neil's (2002) study indicated that there were three statistically significant correlations for group-level teamwork process measures in the knowledge of response feedback groups (adaptability and interpersonal, $r = .38$; adaptability and communication, $r = .39$; decision making and leadership, $r = .63$). The three correlations noted in the adapted knowledge of response feedback groups (all messages sent and decision making, $r = .63$; all messages sent and interpersonal, $r = .54$; all messages and communication, $r = .69$), although statistically significant was not unexpected because these correlations were between "all messages sent" (the sum of the other teamwork process messages) and each teamwork process. There were no other statistically significant correlations. Descriptive statistics indicate that the mean group outcome measure (construction of a concept map) was higher in the adapted knowledge of feedback groups (M=10.93) than the knowledge of response groups (M=8.87). Feedback, one of the problem-solving measures, was statistically significantly correlated with group outcome (knowledge of response groups, r=.45; adapted knowledge of response groups, r=.41). According to the researchers, an unexpected result was that searching was statistically significantly related negatively to group outcome (r = -.40). Hsieh and O'Neil hypothesized that, although participants received feedback on their level of improvement in the adapted response feedback group, they probably would have benefited from more task-specific feedback on search strategies.

Key elements from Chung, Dennis et al.'s (1999) and Hsieh and O'Neil's (2002) studies that are applicable to the current study that utilized a computer-mediated environment are the use of certain types of predefined messages and the encouragement of message sending during game play (not predefined) to support collaborative problem-solving processes.

Digital Game-based Learning

Because software and hardware technologies to support digital game-based learning (DGBL) have advanced rapidly since 2000 with tools that support high-level interactivity, collaboration, engaging 3D graphics, and robust networks that support higher classroom student to computer ratios (Freitas, 2006; Hannafin & McDonald, 2003; Kelley & Ringstaff, 2002; Kirriemuir & McFarlane, 2006; Kulik, 2003; Penuel, 2006; Stefl-Mabry, Radlick, & Theroux, 2006), the literature focus will be limited to results of current studies and reviews of studies published since 2000 (one exception is a meta-analysis of instructional simulations published in 1999) that reflect the impact of newer-generation computer games on learning. Moreover, although the majority of DGBL research has concentrated on examining the impact of game play on gender representation, addictive qualities of gaming, motivation in gaming, self-esteem, and gaming's relationship to aggressive behavior, the study was concerned with the cognitive impact of game playing.

The number of recent research studies on new-generation games that allow players to interact with the environment, maneuver through realistic situations, control various aspects of the game, and experience learner-centered constructivist activities (e.g., MMOGs), is limited (Black, Boyer, Dipietro, & Ferdig, 2007; Egenfeldt-Nielsen, 2007; Jenkins & Squire, 2003; Laughlin & Marchuk, 2005). Laughlin and Marchuk referred to these new-generation games as *fourth-wave* games, whereas Egenfeldt-Nielsen referred to them as games with a *third-generation* approach. These *fourth-wave* games are distinct from the more traditional educational software games that dominate the market referred to as *third-wave* games (Anderson & Buckley, 2006; Laughlin & Marchuk). The third-wave games, although popular, lack the sophistication and potential of the fourth-wave games due to the deficiency of the aforementioned features. They are simple in design and complexity, have little built-in intrinsic motivation, lack integrated learning, fail to use the teacher as the facilitator and debriefer of the game-playing experience, and often are relegated to drill and practice (Egenfeldt-Nielsen; Jenkins & Squire). The discussion of simulation, computer, handheld, and MMOG game studies focuses on newer-generation games many of which would be classified as third- and fourth-wave games.

Many of the research studies on new-generation electronic gaming and student achievement, although generally positive, often contain methodological flaws such as small sample sizes, no control or comparison groups, and relatively short or unequal durations of the experimental phase (Egenfeldt-Nielsen, 2007; Laughlin & Marchuk, 2005; Ritterfeld & Weber, 2006).

Computer-based, Handhelds, and Console-based Games

In their review of the literature on computer-based games and learning, Mitchell and Savill-Smith (2004) and Kirriemur and McFarLane (2006) investigated relevant gaming and learning literature that included the general benefits of computer games, how and whether computer games can be used for formal learning, what educators can learn from game-playing behaviors, and examples of studies of the use of computer games to encourage learning.

Mitchell and Savill-Smith (2004) as well as other researchers (Calao & Din, 2001; Correa et al., 2003; Gee, 2003; Katsionis, Manos, & Virvou, 2005; Kirriemuir & McFarlane, 2006; Ritterfeld & Weber, 2006) cited a variety of learning benefits of computer-based games such as knowledge acquisition, retention, recall of factual content, creative and critical thought, decision making, the development of strategic skills, and problem solving. Recent studies have focused on the effect of computer-based, handheld, and console-based games on student achievement in subjects such as mathematics, reading, and spelling, often focused on elementary-aged students.

Mitchell and Savill-Smith (2004) highlighted a study of disadvantaged, low-performing first and second graders in Santiago, Chile that used a videogame similar to a handheld *Nintendo Gameboy* with embedded learning content to reinforce mathematics, reading, and spelling skills. The experimental group (n= 758; 19 classes) played the game for 12 weeks for 20 to 40 minutes per day while an internal (same school as experimental group) and external (different school than experimental group) comparison group (n= 347; n=169, respectively) received traditional instruction. In separate analyses of covariance, planned comparison results based on pre- and posttest measures indicated a statistically significant difference in means for mathematics and spelling scores between students in the experimental schools (experimental or internal comparison groups) and the external comparison groups. In reading comprehension, no statistically significant difference in means was found between the scores of students in experimental schools (experimental or internal comparison groups) and students in the external comparison groups. No statistically significant mean differences were found between the experimental and the internal comparison groups. Based on teacher observations and reports (students preferred video-game play over other classroom or recess activities) video-game play resulted in improvement in students' motivation to learn.

Due to the inconsistent length of time that students in the experimental groups engaged in video-game play (ranged from 20 to 40 with an average of 30 minutes each day), this methodological flaw questions the validity of the research results.

In a similar study of disadvantaged African-American kindergarten students (n=24, experimental group; n=23, comparison group), Calao and Din (2001) conducted a study of the use of handheld *Sony Playstation*-type games (students engaged in 70 minutes of game play per day over a period of 11 weeks) containing kindergarten academic content. The Wide Range Achievement Test-R3 (WRAT-R3) was utilized as a pre- and posttest measure. Results indicated increased means between the pretest and posttest in the experimental and comparison groups in mathematics, spelling, and reading. The difference in means was not statistically significant between the experimental and comparison groups in mathematics, spelling, and reading; however, the posttest means in spelling (M= 14.63) and reading (M= 15.29) were higher in the experimental group than the comparison group (M=14.00, M=14.09, respectively). The comparison group (M= 10.22) outperformed the experimental group (M= 9.54) on the mathematics measure. As in Calao and Din's (2001), study a methodological flaw was evident in this study: the experimental group received 350 minutes of game play (40 minutes during the school day and an additional mandatory 30-minute game-play session each evening at home) each week for 11 weeks in addition to traditional instruction in spelling, mathematics, and reading, whereas the comparison group received 11 weeks of traditional instruction only. With the relatively modest difference in means favoring the experimental group in spelling and reading and no higher means in mathematics with 350 minutes of game play, the results do not prove to be compelling. Furthermore, small sample sizes may have resulted in low power.

Lee, Luchini, Michael, Norris, and Soloway (2004 April) conducted a pilot study of 39 second-grade students (19 students in one classroom and 20 in another classroom) who used *Nintendo's Gameboy Advance* handheld as the platform for playing *Skills Arena*, a mathematics video game designed to supplement traditional mathematics instruction. The pilot study compared student use of a mathematics-related video game as opposed to traditional worksheets and studied student achievement during video-game play. The object of the game was for student's self-created characters to solve the *opponent's* addition and subtraction problems (a 2-minute game match) at varied levels of difficulty as they move across the screen. Players received instant feedback on correctness of answers, percentage correct, and used tools to alter mathematics problems to provide more conceptual control (9 +7 can be manipulated to 10 + 6).

After a 19-day test period (Test period 1 – 10 days; Test period 2 – 9 days) where one classroom of students played *Skills Arena* for 10 minutes per day and another classroom of students played *Skills Arena* for 15 minutes per day, log files were analyzed to ascertain the average number of problems answered per student.

Results indicated that students answered 12,113 of 17,740 questions correctly (68%) during Test Period 1. During Test Period 2, 17,786 of 32,786 questions (54%) were answered correctly. On average, students answered 1,296 problems during the 19-day pilot period compared with a typical 456 problems during the same time frame using traditional worksheets and played an average of 77.38 minutes. Although the percentage of correct answers dropped between the two test periods, researchers indicated that during Test Period 2 students increased the difficulty of the game by increasing the speed at which questions traveled across the screen, thereby nearly doubling the number of problems answered in the second test period. This desire for a consistent balance between challenge and skills is evident in the majority of game players. In addition, of interest for this study is the collaborative problem solving that evolved during the 19-day pilot study. Researchers noted in the pilot study the student's natural collaborative interaction and the explorative success of the collaborative use of the Tools Options (conceptual-control aspects of the game) during game play without explicitly having been taught the how to use the options.

In another third-generation game directed at elementary-aged students that illuminates problem-solving aspects of game play, Ko (2002) studied children's decision-making, logical-reasoning, and inferential-game playing abilities. Two groups of students aged 6 to 8 and 9 to 10 were assigned randomly to play a board game or computer-based game called *Find the Flamingo*. Each student played the game individually eight times each. The object of the game was to use clues (indicators of HOT, WARM, or COLD) to find the Flamingo hidden behind one of 25 cards. It was presumed that students would use trial and error or use clues (e.g., if the flamingo touches your box sidewise, you are hot) to find the flamingo.

Results were measured by counting the total number of moves until game completion (finding the flamingo) as well as the number of "single information inference" (a move based upon inference from previous information received). If individual moves were fewer than 7.07 over eight games, it was deemed not to be chance that the flamingo was found but rather inferences based upon calculations related to various mathematical assumptions.

Forty-eight out of the 55 ten-year-old student's mean moves were fewer than the criterion 7.07 moves, whereas only 13 of the 32 seven-year-old student's mean moves were less than the criterion, a statistically significant difference. In addition, the older students, outperformed the younger students by more frequently making correct use of the clues WARM and COLD (65 vs. 28 correct uses and 75 vs. 42 correct uses, respectively). Both groups made high use of the clue, HOT (90 uses for the 10-year-old group and 88 for the 7-year-old group). Poor game players (started the game with less efficiency and the mean number of moves in the last four games was greater than 7.07) consistently played the game poorly, whereas good game players (started the game with high efficiency and mean number of moves in the last four games was less than 7.07) consistently played better from the first game on. There were no statistically significant gender or media (computer versus board game) differences between groups.

Ko (2002) summarized that students who made fewer moves within the game-playing environment approached the game as a problem-solving task. These students used problem-solving strategies to identify logical relationships and used inferences to guide decision making and to calculate moves. Although no statistically significant difference was found between traditional game play (board game) and computer-based game play related to problem-solving efficiency, Ko observed a higher level of student motivation in playing the computer-based game than the board game and suggests that further research is needed to further analyze how thinking and learning happens during computer-based game play if educators are to make technology-based games central to the learning environment. While distinct in design, the study examined thinking and learning during game play, specifically collaborative teamwork processes within a MMOG environment and the impact on individual achievement.

MMOGs

Very few empirical studies exist on the impact of MMOGs on academic achievement. Dede and Ketelhut (2006) conducted research on the impact of a Multi-user Virtual Environment MUVE (similar to an MMOG as previously stated) on students' inquiry skills, motivation, and academic performance. Research participants were 81 low-performing and low-socioeconomic middle-school students from Boston Public Schools. The focus of the research was on improving students' experimental-design skills, a difficult concept for students to grasp according to a sampling of middle-school science teachers. Students were assigned randomly to one of two groups: 45 total students in the experimental group (one group from School A and one group from School B) and 36 total students in the control group (one group in School A and one group in School B).

The MUVE, an engaging immersive 19th-century world called *River City,* contained informational video and audio support artifacts and an ability to interact with peer- and instructor-avatars to assist students in reinforcing their skills in biology and ecology as they attempted to solve environmental and health problems. Quantitative and qualitative data that measured content knowledge and constructs such as attitudes about science, academic efficacy, metacognitive awareness, and collaboration, were collected during a 3-week research period. Results on the pre- and posttest scores indicated that students in the experimental group showed a 3% gain on the posttest for the experimental group and a 4% gain for the control group with lower-performing students making the highest gains. Lower-performing students also showed the highest gains on the multiple-choice posttest when they started with high metacognitive awareness.

The experimental groups' academic efficacy grew by one point, whereas, the control groups' academic efficacy declined by .31 points, a statistically significant difference. There was also a statistically significant difference between the experimental group (unchanged between the two measures) and the control group (mean decline of 2.4 points) in motivation. Of special interest for the purpose of the current research was the finding that the experimental groups' growth in collaborative problem solving led to increased motivation and higher-level academic performance.

Simulations

The majority of studies have focused on computer simulation (reality-based games that allow individuals direct experience in the replication of a social or physical event) because of the wide use in military and business for training purposes (Anderson & Buckley, 2006). Even though a variety of learning outcomes come as a result of simulations such as enhanced computer and metacognitive skills, improved strategic thinking, pattern recognition, and deep-level problem solving (Mitchell & Savill-Smith, 2004), instructional simulation studies have received mixed results in the literature (Lieberman, 2006). In her meta-analysis of instructional simulation studies, Lee (1999) examined 19 studies that met three criteria: studies with quantitative information where effect sizes could be calculated, studies with a control or comparison group other than the simulation group, and studies that did not demonstrate significant methodological flaws. Two types of simulations, presentation (simulations for teaching new knowledge) and practice (simulations used for reinforcing and integrating information of which students are familiar), were used in each of the studies. The majority of the comparison treatments were traditional lectures and computer-based tutorials. Academic achievement was assessed in a variety of knowledge domains such as statistics, science, physics, and geography with science studies being the dominant subject area. The overall mean effect size for academic achievement based on posttest scores was .41 (the average experimental-group student was two-fifths a standard deviation more improved than the average control-group student on the outcome measure), a moderate but educationally meaningful effect. Lee suggested that a confounding variable exists in many simulation studies: the lack of consistency in the quality of the instructional treatment between the control and the simulation groups with more time typically invested in the preparation of instructional materials for the simulation groups than the control group and the comparative quality of the simulations being utilized in the studies. Furthermore, Lee concluded that in addition to overall effect-size measures, researchers should more narrowly define how to use simulations as teaching tools that lead to higher achievement. The varied results in Kulik's (2003) analysis of several simulation studies underscore this point.

Results of Kulik's (2003) analysis of six dissertation studies, five from high-school science courses and one from a middle-school science course, were mixed. In three studies, the nonsimulation group outperformed the simulation groups. In two studies, the simulation group outperformed the nonsimulation group. In one study, the simulation group outperformed the nonsimulation group on one outcome measure, whereas the nonsimulation group outperformed the simulation group on the other outcome measure. The median effect size of the six studies for achievement was .32 (performance at the 63rd percentile). In the majority of the studies, simulations produced positive effects when they (simulations) were used as preparation for a learning activity, as a remediation tool, and as supplements. Based on these results, Kulik contended that the use of computer simulations would benefit from further study, a similar conclusion of Lee (1999), because research indicates that the use of simulations does not guarantee achievement success; therefore, teachers should exercise care in deciding how and when to use simulations and which simulations to use.

Two recent research studies looked at specific methods for designing instruction to make the best use of simulations to support learning. Rieber, Tribble, and Tzeng

(2004) used a researcher-designed simulation to teach aspects of Newton's laws of motion (relationship between acceleration and velocity). In the study, participants (52 college juniors and seniors enrolled in a computer-education course) controlled the acceleration of a ball and were instructed to move the ball to a specific screen location (30 trials with increased difficulty in the last 10 trials to introduce a challenge aspect) in a simulation designed to represent the underlying mathematical model of the principles of motion physics. The focus of the research was to examine the effect of graphical animations including a multimedia element (brief, embedded multimedia segment that explicitly explained the physic's principles) and textual feedback represented by numeric expressions of the simulation on learning. The results of the posttest outcome measure (a 20-item multiple-choice test whose questions measured the participants' ability to apply the principles of Newtonian motion in simple situations) was statistically significant indicating that participants who received graphical feedback with the multimedia explanations (M=93.5) outperformed participants receiving textual feedback (M=74.2).

Mayer, Mautone, and Prothero (2002) conducted several studies, two of which are discussed below, on the type of student guidance needed (no guidance, pictorial scaffolding, verbal scaffolding, and pictorial and verbal scaffolding combined) as students interacted with a simulation to complete an authentic geology-based problem-solving task. Scaffolding is defined as any type of cognitive support that is provided to the learner. The authentic task was to survey an area of a planet's surface to identify various geological features and to indicate whether the feature was on land or in the ocean. The game required thinking skills to gather and interpret geologic data as participants devised a systematic approach in using lines and points. Visualization skills were used to create mental images using the collected data as to which geologic feature was being represented. Rather than focus on the value of simulations, Mayer et al.'s study focused on the conditions for which a particular medium within a simulation is most effective. In the first experiment, 13 of 28 students from a Psychology Pool of Subjects at the University of California, Santa Barbara were assigned randomly to a no-modeling group (received paper-based instructions to complete the problem and were directed to sections of the instruction pages in response to any questions they had; the experimenter controlled the sequence of geologic features that participants identified within the simulation) and 15 were assigned to a modeling group (received the same paper-based instructions and verbal experimenter modeling of how to complete the first problem) to solve four problems. The outcome measures utilized were the number of target problems answered correctly (problems 2 to 4 out of 4 problems; the solving of problem 1 was solved by both groups but was used by researchers to demonstrate *modeling* in the treatment group). A problem was scored correct if participants identified the correct geologic feature and whether the feature was on land or ocean. In addition, the time in seconds to solve the problem was assessed by subtracting the time elapsed between when a problem was selected by the experimenter and when the final answer was submitted. Results indicated that there was no statistically significant difference in the number of problems solved correctly between the modeling (M=1.60) and the no-modeling (M=1.77) group. Also, there was no statistically significant difference in the number of seconds used to solve the problems in the modeling (M=1,133) and the no-modeling group (M=1,091). Mayer et al. hypothesized that the failure to improve student learning in the modeling group was due to three factors: the experimenter provided verbal feedback to learners who were completing a visual task and because the instruction booklet was verbal as well, the modeling may not have added beneficial new information; the experimenters merely demonstrated rather than proposed possible strategies; extraneous tasks such as finding the elevation of features may have caused cognitive overload. The researchers conducted a second experiment to test their hypotheses.

The goal of Mayer et al.'s (2002) second experiment was to compare the learning outcomes of students receiving no scaffolding, strategic (verbal) scaffolding, pictorial scaffolding, and both types of scaffolding combined using the same geological simulation game from the first experiment. Participants were 105 students from a Psychology Pool of Subjects at the University of California, Santa Barbara. Twenty-eight were assigned to a pictorial-scaffolding group (received paper-based instructions, were shown land and ocean sketches of the geologic features, and were provided a summary page of the sketches to use while completing the task), 29 were assigned randomly to the strategic (verbal)-scaffolding group (received paper-based instructions, received a six-item strategy summary sheet that was read aloud to them by the experimenter, and were told to use the strategy summary sheet to complete the task), 23 were assigned randomly to both-aids group (received paper-based instructions and were shown the picture sketches and the strategy sheets in the same manner as participants in the pictorial-scaffolding and strategic (verbal)-scaffolding groups, respectively) and 25 were assigned randomly to a comparison group (were provided paper-based instructions for completing the task but received no modeling) to solve five problems.

The outcome measures of the study were the number of problems answered correctly out of five problems. A problem was scored correct if participants identified the correct geologic feature and whether the feature was on land or ocean. In addition, the time in seconds to solve the problem was assessed by subtracting the time elapsed between when a problem was selected by the experimenter and when the final answer was submitted.

Mayer et al. (2002) conducted an ANOVA to determine whether pictorial scaffolding or strategic (verbal) scaffolding or both helped students to learn at a higher level. Results indicated that participants who received pictorial scaffolding solved statistically significantly more problems (M=3.31) than groups who received no pictorial scaffolding (M=2.65); however, there was no statistically significant difference between groups that received strategic (verbal) scaffolding (M=3.11) and groups that received no strategic (verbal) scaffolding (M= 2.83). In addition, the both-aids group (M=3.39) outperformed the comparison group (M=2.36) that received no scaffolding. Pictorial scaffolding produced a moderate effect size of .45, a practically important effect in educational studies. There was no statistically significant difference in the number of seconds used to solve the problems in the pictorial-scaffolding group (M=516) and groups that received no pictorial scaffolding (M= 560). Similarly, there was no statistically significance difference in the number of seconds used to solve problems for groups that received strategic (verbal) scaffolding (M=516) and groups that received no strategic (verbal) scaffolding (M=560). Overall pictorial scaffolding had a positive effect on solving problems in the geology simulation game.

The results of Mayer et al.'s (2002) and Reiber et al's (2004) studies suggest that embedded feedback and scaffolds in the form of multimedia and pictorial aids are useful to support learning when using simulation games. These types of scaffolds are standard in-game supports in an MMOG environment that players utilize as they collaboratively interact during game play. This research study investigated whether positive individual achievement occurs as a result of game playing within an MMOG environment as in Mayer et al.'s study.

Summary

The literature review just presented outlined empirical data that suggest that computer-mediated learning situated in real-world contexts, incorporating collaborative problem solving (teamwork processes), supports learning. Concept-map construction to summarize content is a viable approach to assess learning.

Collaborative problem solving within optimum conditions (e.g., feedback on problem-solving efforts, active participation of all participants, distribution of key information) produces positive academic outcomes because of the combined cognitive properties through group interaction and is enhanced when problem solving is modeled and feedback is provided; however, more data relating to the type of interactions that produce superior outcomes, the focus of this study on the effects of MMOG play, are needed.

Research literature indicates that concept maps are good tools to assess what learners know. Most empirical data on computer-mediated concept mapping demonstrates their use as social thinking tools. Researchers suggest that the academic benefits of collaboratively-constructed concept maps such as enhanced comprehension and raised achievement scores are the appeal of concept maps to individual differences.

The six CRESST teamwork processes has served as a framework to analyze the type of naturally-occurring collaborative teamwork that players utilize to solve problems during game play. Research results indicate that types of messages communicated during a computer-mediated tasks supports collaborative problem solving.

The research literature suggests that technology tools such as computers and video games positively can impact learning; however, there is a need for more empirical data on how to integrate these technology tools and under which conditions these technologies produce the greatest learning effects. The comparison-and-treatment group study in this research, a missing element of many video-game studies, specifically investigated MMOGs, a newer-generation video game, that is congruent with the needs of today's learners, anchored within a social context, and satiated with real-world learning experiences, important learning supports according to learning theorists.

CHAPTER

III. METHODOLOGY

The benefit and significance of collaborative game play through the embedded support mechanisms within MMOGs to master game levels and solve problems are emphasized in much of the literature on MMOGs (Braswell & Childress, 2006; Clarke, Dede, Ketelhut, & Nelson, 2006; Freitas, 2006; Jenkins & Squire, 2003; McCreery & Schrader, 2007). Collaborative game play leads to enhanced player performance, higher retention of information, and enhanced performance in solving complex problems (Jenkins & Squire, 2003).

The purpose of this study was to investigate the impact of collaborative teamwork processes during MMOG play (*Web Earth Online*) on individual achievement. An assessment of the types of collaborative strategies that participants used during game play and the performance of individual players after game play on measures of academic achievement (concept-map construction and pre- and posttest performance) on life-science concepts (life cycle and survival needs of the Eastern Bluebird) was conducted. Performance of game players was contrasted against the academic-achievement performance of comparison groups receiving traditional instruction. The CRESST researchers' model to classify video-game collaborative problem solving or teamwork strategies (Baker, O'Neil, & Wainess, 2005) was utilized in this study.

This chapter includes details regarding the research design, the demographics of the school-study site and the participants, the methods utilized for the protection of human subjects, detailed study procedures for the experimental and comparison groups, the treatment instruments employed in the study, and data-analysis methodology.

Research Design

The research design was a quasi-experimental design. The independent variable was group (experimental groups that received a treatment of MMOG game play and comparison groups that received traditional instruction). The dependent variable was players' individual performance on two measures: a multiple-choice traditional knowledge-assessment test and construction of a concept map, both based on the ecology-based unit of instruction on the Eastern Bluebird. Pre- and posttest measures were utilized for the traditional assessment, whereas, a concept-map construction measure was utilized at the end of the treatment period. The log files of player dialog during game play were coded to assess the type of collaborative problem-solving strategies that players used during game play. Independent-samples t tests were utilized to test for differences in means in the change from pre- to posttest (traditional assessment) between the experimental and the comparison groups. An analysis of variance (ANOVA) was used to assess whether means on the dependent variables differed statistically between groups. A content analysis of log-file dialog was utilized to assess collaborative teamwork processes.

Participants

Participants (Table 1) in this study were 159 sixth-grade male and female students from a Western Association of Schools and Colleges (WASC)-accredited private Christian junior-high school located in the heart of the Silicon Valley in San Jose, California. There were four comparison groups of existing, intact sixth-grade classes ($n=100$), 2 taught by the researcher and 2 taught by the regular sixth-grade science teacher. There was an experimental group of two existing, intact sixth-grade classes (n=59) taught by the researcher. Of the 159 participants, there were almost a third as many females as males. Sixty-five of the participants were 12 years old, and 93 were 11. One was 13 years old.

Table 1

Frequency Distribution of Age and Gender Across the Three Groups (n=159)

	Experimental		Comparison R		Comparison T	
Demographic	f	%	f	%	f	%
Gender						
Male	18	11.3	30	18.9	18	11.3
Female	41	25.8	27	17.0	25	15.7
Age						
11 yrs	35	22.0	33	20.8	25	15.7
12 yrs	24	15.1	23	14.5	18	11.3
Total	59		57*		43	

Note. This group also contained one 13-year old, not included in the table data. "Comparison R" represents the two groups taught by the researcher and "Comparison T" is the teacher.

The junior-high school is part of a school district that has one elementary, one junior high, and one high school. There is a total school enrollment of 2,200 students. The socioeconomic status of the majority of students is moderate to high. The ethnic breakdown of the junior high was as follows: African American 6%, Asian 16%, European American 61%, Hispanic American 12%, and Pacific Islander 5%. The percentage of students at the junior high who were performing above the 50^{th} percentile on standardized tests (Stanford Achievement 10) was 80.9% for reading and 85.2% for mathematics. Eighty-one percent of sixth-grade students met or exceeded the standards on the school-based writing proficiency assessment. Ninety percent of sixth-grade students earned a science grade of an A or B in the first quarter of the 2007-2008 school year. No sixth-grade students had an Individualized Education Program (IEP) or were in need of special accommodations. Forty percent of students were from the district's elementary feeder school. The fifth-grade classroom experiences of students from the elementary feeder school were technology-infused with student and teacher use of computer-based tools such as Microsoft Word, Excel, Powerpoint, video-editing, keyboarding, and Internet to support teaching and learning. One teacher taught all sixth-grade junior-high science courses (six class periods with an average of 30 students per period).

Protection of Human Subjects

Consideration of protection of human subjects was addressed by applying to the University of San Francisco's Institutional Review Board before conducting human subject research. The ethical principles and standards outlined by the American Psychological Association (2002) for human-subject research was adhered to. Parents of students who agreed to allow their students to participate in the research did so using a passive consent. The passive consent form was designed to be returned signed by parents or guardians only if parents or guardians did not wish for their child to participate. The parent's consent allowed their students' data to be used in the study.

The junior-high-school administrator, parents, and participants were advised of the purpose of the research during the recruitment process. The junior-high school administrator and sixth-grade teacher gave written permission to the researcher to conduct the research with the sixth-grade participants. The scope of the research and the expected research period over 8 days for a 55-minute period each day was explained to parents and participants.

Parents of participants were advised that their consent was requested to allow the researcher to use the aggregate demographic, pre- and posttests, concept-maps, and log-file data. Participants also were advised that anonymity would be protected through the issuance of unique identification (ID) numbers provided when the researcher registered participants for individual *Web Earth Online* accounts for the experimental group and teacher-issued ID numbers for the comparison group. Parents and participants were informed that the teacher would keep a list of IDs in case students forget their ID and that the list would be kept in a separate location from the data and destroyed after the data were collected at the end of the study. Participants were advised that collected data would be kept in a secure location that would only be accessed by the researcher. Students were provided with their pre- and posttest data and concept maps at the end of the instructional unit. Students were graded on the completed work during the treatment period.

Pilot Study

Prior to conducting the formal study, the researcher conducted a pilot study with seventh-grade students. The focus of the pilot study specifically focused on issues related to the Web Earth Online, an ecology-based MMOG. As participants' bluebird avatars sought to survive in a reality-based habitat, the researcher was concerned with participant's impressions of the game interface.

The pilot study (three 3-hour *Web Earth Online* game play sessions) was approved by the University of San Francisco's Institutional Review Board. All precautions were taken to eliminate any possible risks to participants. Participants were advised that the testing of the virtual environment was not an attempt to promote the MMOG. Subjects were advised that pilot-study data gathered was confidential and would coded and maintained in a locked file, that identities would be protected, and that data would be destroyed at the completion of the research. Participants also were advised that they could withdraw from participating in the pilot study at any time. Because the researcher was a member of the executive team, students were familiar with the individual conducing the pilot study. In addition, security concerns of parents were minimized because the applicant has the appropriate clearances to work with students. Participants were advised that the data gathered in the pilot study would not affect their grades.

The pilot study was conducted in the Fall of 2007 with 11 seventh-grade students to assess research tools and learning activities of the current research study.

Participants who volunteered for the pilot student played *Web Earth Online* from 9:00AM to 12:00PM for three consecutive Saturdays. Frequent breaks were provided for snacks, bathroom, and social time. Each participants' name was entered into a drawing for each pilot study session attended (e.g, if Student A attended all three pilot-study sessions, their name was entered into the drawing 3 times) for a digital camera. The name of the winner of the camera was drawn at the end of the last day of the pilot study.

Participants were administered a *Game Experience Survey* and a multiple-choice academic achievement test on the survival needs of the Eastern Bluebird on the first day of the pilot study. A *Game Satisfaction Survey* and the same multiple-choice achievement was administered on the last day of the pilot study. Participants also constructed individual concept maps on the Eastern Bluebird on the last day of the pilot study.

The pilot study took place in a self-contained computer laboratory. Each student was assigned his or her own desktop computer to play *Web Earth Online.* Participants were given access to a *Web Earth Online* tutorial via the school's learning management system, Moodle, to help them understand the game. The game developer was available during game play during the pilot to provide support technical support and to answer game-based questions. Connection was lost three times over the 3-day pilot period: one due to an ice storm in Kansas where the game servers were located and twice because of server issues that were corrected by the game developer. All researcher-initiated and student-generated questions about the game interface were answered satisfactorily. In addition, the researcher and game developer communicated by phone and email on a regular basis to discuss the game features and progress in the research.

Of the 11 students, the majority had previous game-play experience. Only one student had never played video games. Sixty-three percent indicated that they played often, 72% considered themselves videogame experts, and they all had played using avatars. Twenty–seven percent of pilot-study participants viewed themselves as marginal players. The majority of students were accustomed to the typical game interface.

Data gathering during the pilot study was focused on the following: (a) length of time that players take to move accomplish tasks within the game; (b) analysis and coding of dialog from log files using CRESST's classification of collaborative problem-solving strategies; (c) pre- and posttest data to measure learning of science content; (d) unanticipated technical or interface problems experienced during game play; (e) previous video game, MMOG, or both experience; (f) the amount of time that players engaged in *Web Earth Online* game play outside of the pilot study period; (g) player satisfaction with *Web Earth Online*; and (h) test researcher-designed instruments used to measure learning of science content (pre- and posttest and concept maps). Modifications to procedures and instruments were made based on results of the pilot study.

Results of the pilot study indicated that players within the first 3-hour game-play session on Day 1 of the pilot study, were able to master the basic elements of game play (eating, drinking, flying, understanding the purpose of the clickable game tools, beginning nest building). In the successive 2 days of the pilot study, each of the 11 students advanced in the game by successfully building nests, mating, and raising young.

Initial analyses of the chats indicated that dialog could be coded to into the six collaborative problem-solving areas. In the 3 days of the pilot study, students generated multiple pages of dialog, a large percentage of the dialog being social conversation typical of the age of the learners. Student achievement scores improved from the multiple-choice pretest to posttest indicating that learning took place. Minor adjustments were made to the wording of some of the test items based on student questions about terminology. Because there were only 11 participants, reliability could not be assessed in the small sample.

Students were able to construct individual concept maps based on what they learned about the life cycle and survival needs of the Eastern Bluebird. Some maps were more elaborate than others as is the case with the majority of learning tasks. No statistical analyses were conducted on game satisfaction, but all 11 students raised their hands indicating that the game play had been a positive learning experience.

In reviewing the survey instruments, the researcher did reverse code select items to raise the reliability levels in anticipation of the formal study. In addition, the researcher decided to "time stamp" the chat dialog for the final study rather than solely "date stamp" to obtain additional chat-dialog information.

Students did express some frustration at the beginning of game play because the game was "slower" than the higher-quality game engine MMOGs. Based on chat-log data, it was apparent that students did engage in game play outside of the pilot period indicating that the game was motivating and engaging.

Treatment

The participants were separated into two experimental and four comparison groups. The researcher taught 2 experimental groups (periods 5 and 6; 59 students total) and 2 comparison groups (periods 1 and 7; 58 students total). The sixth-grade science teacher taught 2 comparison groups (periods 2 and 3; 43 students total). The treatment for the experimental group was the *Web Earth Online* MMOG (Figure 1).

Web Earth Online is a complex 3-dimensional MMOG with varied levels of play. The game immerses players into a realistic ecosystem of animals of various species. Players play the role of various animals moving through each animal's entire life cycle. The object of the game is for players to understand and respond to the needs of their animal and to make the necessary decisions to optimize the survival and the propagation of the animal that they are playing. The first default animal in Web Earth Online is the Eastern Bluebird. For the purpose of the current study, participants only played the bluebird and no other animals during the experimental period. Built-in game hints assist players in optimizing their animals' chance of survival. Players accumulate points as the survival needs of their animal (the bluebird) are met. Bluebirds also may die if survival needs are not met; however, within the game world, players have the opportunity to

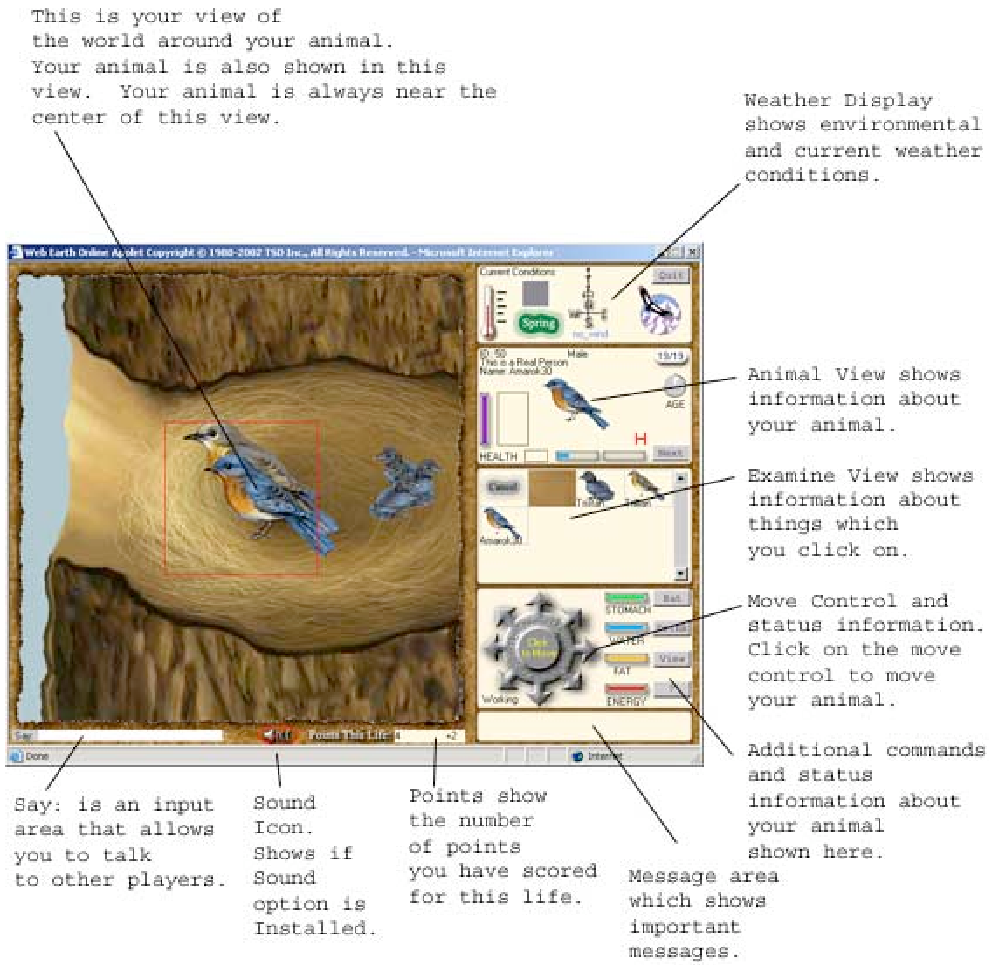

Figure 1. Web Earth Online Game Interface

start over again by becoming a new bluebird and continuing game play. A researcher-designed tutorial (Appendix A) demonstrating the *Web Earth Online* interface and how to play the game was developed and stored in an online course development portal (*Moodle)*. On Day 2 of the formal study participants (experimental group) were provided instructions on how to access the *Web Earth Online* tutorial to gain familiarity with the game interface.

The comparison groups received traditional researcher-designed instruction about the Eastern Bluebird that contained the same content as the instructional MMOG. The unit of instruction included daily learning objectives supported by researcher-designed

PowerPoint® presentations, supplementary audio bytes and video clips, nonfiction books and hands on group activities. The *Web Earth Online* MMOG and the instructional unit addressed the learning goals of the following California's sixth-grade life-science academic content standards:

> Organisms in ecosystems exchange energy and nutrients among themselves and with the environment. As a basis for understanding this concept:
> 1. Students know matter is transferred over time from one organism to others in the food web and between organisms and the physical environment.
> 2. Students know populations of organisms can be categorized by the functions they serve in an ecosystem.
> 3. Students know different kinds of organisms may play similar ecological roles in similar biomes.
> 4. Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.
>
> *Science Content Standards for California Public Schools, 2000 p.20*

In addition, a researcher-designed concept-map module was incorporated into the instructional program in the experimental and comparison groups. The sixth-grade curriculum utilizes preconstructed concept maps in the traditional science instruction, a concept that is difficult for the majority of students based on the assessment of student performance by the current sixth-grade science teacher. Because of the need to review student concept-mapping skills, the researcher and science teacher taught an instructional review module on concept maps (25 minutes) to their respective groups on the first day of the study to students in the traditional and comparison groups.

Procedures

The researcher consulted with the teacher to determine whether there were special considerations in determining which 4 of the 6 classroom periods were more appropriate for the researcher to instruct during the research study and none were articulated.

The junior-high-school administrator was contacted in person to seek the school's permission to conduct the research. Once permission was received, a letter of endorsement from the junior-high principal (Appendix B) and sixth-grade science teacher (Appendix C). A passive consent form (Appendix D) was mailed to the sixth-grade parents of students in the 6 participating periods advising them of the research study and seeking their consent to allow the researcher to use the aggregate demographic, pre- and posttest, concept map, and log-file data. The contact information of the researcher was provided to parents in both of the above correspondences should they have had questions about the research study. After parents provided permission for their students to participate in the research study by not signing the passive consent form and approval was granted from the University of San Francisco's Institutional Review Board, the researcher initiated the study. A parent signature on the form indicated that their student's data could not be used in the study; however, all students participated in the learning activities because the activities were part of the regular academic content. The study was carried out in January 2008.

The treatment period was organized based on the middle-school rotating schedule (Figure 2). Four periods of sixth-grade students received researcher-led (2 periods) and teacher-led (2 periods) traditional (comparison group) instruction utilizing a researcher-designed unit of instruction for 55 minutes on the life cycle and survival needs of the Eastern Bluebird. Two other periods of sixth-grade students (30 students in first period and 29 students the second period) played *Web Earth Online* to learn about the life cycle and survival needs of the Eastern Bluebird. Students played *Web Earth Online* in the library computer laboratory that was reserved for the duration of the study. The *Web*

DAY	1	2	3	4	5	6	7	8	9	10	11
Class Period 55 minutes	M	T	W	Th	F	M	T	W	Th	F	M
Period 1		Concept Map Lesson	Pretest CGR Bluebird Unit	Bluebird Unit	Bluebird Unit		Bluebird Unit	Bluebird Unit	Bluebird Unit	Bluebird Unit	Bluebird Unit USS
Period 2	Concept Map Lesson		Pretest CGT Bluebird Unit	Bluebird Unit	Bluebird Unit	Bluebird Unit		Bluebird Unit	Bluebird Unit	Bluebird Unit	Bluebird Unit USS
Period 3	Concept Map Lesson	Pretest CGT Bluebird Unit		Bluebird Unit	Bluebird Unit	Bluebird Unit	Bluebird Unit		Bluebird Unit	Bluebird Unit	Bluebird Unit USS
Period 5	Concept Map Lesson GES	Pretest EG WEO	WEO	WEO		WEO	WEO	WEO	WEO		WEO GSS
Period 6	Concept Map Lesson GES	Pretest EG WEO	WEO	WEO		WEO	WEO	WEO	WEO		WEO GSS
Period 7	Concept Map Lesson	Pretest CGR Bluebird Unit	Bluebird Unit		Bluebird Unit	Bluebird Unit	Bluebird Unit	Bluebird Unit		Bluebird Unit	Bluebird Unit USS

Abbreviation Key

- EG Experimental Group
- CGR Control Group Researcher
- CGT Control Group Teacher
- GES Game Experience Survey
- GSS Game Satisfaction Survey
- USS Unit Satisfaction Survey
- WEO Web Earth Online

Day 12 &13
Posttest
Concept Map Assessment
ALL GROUPS

Figure 2. Rotating schedule of experimental and treatment groups

Earth Online game developer and an environmental science teacher evaluated the unit of instruction to ensure that the content in the instructional unit was consistent with the content learned in *Web Earth Online*.

The instructional activities in the comparison group provided rich, hands-on contextual experiences as students learned about the Eastern Bluebird (Appendix J). The researcher decorated classroom walls with artifacts that reflected animal habitats including habitats that were ideal for the Eastern Bluebird and habitats that were not. One classroom wall provided a “closeup” of the bluebird habitat (a tree cavity). Students were provided resources that students could use to learn more about the Eastern Bluebird such as reference books, children’s books, poems, photos, nest boxes, sound files, and music.

The reference materials also included information on the survival needs of the Eastern Bluebird. The academic content standards that were addressed during the course of the unit were listed on butcher paper and posted in a prominent location in the classroom. The academic standards that were addressed were referred to often during the instructional unit. Examples of student activities included habitat role-play games, building bird nests, bird-call mimicry, guided research to answer student-generated questions about the bluebird, reflective writing, and Internet-based bluebird observations.

The researcher led two periods of instruction for the comparison groups and the sixth-grade science teacher led two periods of instruction for the other comparison groups. The researcher taught the remaining two remaining periods (experimental groups). The science teacher followed the instructional format of the researcher for each day of the study.

Although the learning activities for the comparison and experimental groups were distinct, the focus of the instructional unit (ecology-based unit on the Eastern Bluebird) and the academic content standards were the same (Table 2).

On Day 1 of the research study, the researcher introduced the learning goals for the treatment period, reviewed behavior expectations, and gave students very brief post-holiday sharing time. This orientation was followed by a 30-minute instructional module on concept maps (a modified version of the Concept Map Unit of Instruction designed by Ken Plummer from Brigham Young University) and 15 minutes of guided practice-group activities on concept maps. The experimental group only had 10 minutes of concept-map guided instruction because they also completed the 5-minute *Game Experience Survey* (Appendix E).

Table 2
Learning Activities in the Experimental and Comparison Groups

Treatment Period	Groups: Experimental	Groups: Comparison
Day 1	Introduction of learning goals Behavior expectations Brief post-holiday sharing 30-minute concept map instructional 10-minute concept map practice 5-minute Game Experience Survey	Introduction of learning goals Behavior expectations Brief post-holiday sharing 30-minute concept map instructional 15-minute concept map practice
Day 2	25-minute Pre-assessment (Bluebird) 30-minutes Web Earth Online	25-minute Pre-assessment (Bluebird) 30-minute Lesson 1 Instructional Unit
Day 3	*Web Earth Online* game play	Lesson 2 Instructional Unit
Day 4	*Web Earth Online* game play	Lesson 3 Instructional Unit
Day 5	*Web Earth Online* game play	Lesson 4 Instructional Unit
Day 6	*Web Earth Online* game play	Lesson 5 Instructional Unit
Day 7	*Web Earth Online* game play	Lesson 6 Instructional Unit
Day 8	45-minute *Web Earth Online* game play 10-minute Game Satisfaction Survey	45-minute Lesson 7 Instructional Unit 10-minute Unit Satisfaction Survey
Day 9	25-minute Posttest (Bluebird) 30-minute Concept Map Construction	25-minute Posttest (Bluebird) 30-minute Concept Map Construction

Participants in the experimental group used the library computer laboratory where there is a one-to-one computing environment (a computer from every student with no need to share) to play *Web Earth Online*. On Day 2, participants in both groups used 25 minutes of the class period to complete a multiple-choice assessment on the life cycle and survival needs of the Eastern Bluebird (multiple-choice academic content test; Appendix F). Each participant in the comparison group received a teacher-selected ID number to provide anonymity for the performance measures that they completed, whereas each participant in the experimental group received unique default ID numbers that were assigned from registration in the *Web Earth Online* MMOG. Students were given the remainder of the class period to play *Web Earth Online*. Students were advised that a researcher-designed tutorial through the school's content-management portal (Moodle) was available to learn the game interface. Few students chose to utilize the web tutorial but chose to begin game play immediately.

The experimental group played Web Earth Online in three private (password-protected) fully functioning virtual worlds (the Eastern Bluebird habitat) that could only be accessed by students in the experimental groups. No outside players from other locations had access to play in the private game worlds; however, computer-controlled animals (NPCs) existed in the world along with the participants' player-controlled animals to allow for an authentic experience within the game. Each world allowed a maximum of 10 players. The researcher assigned randomly each of the 59 players from the two experimental groups to the three private worlds. The smaller groups allowed for more efficient dialog among the participating players with whom they collaborated.

Participates were encouraged to collaborate during game play providing support to other players through the game-play dialog (message sending) feature. A paper-based example message from each of the collaborative problem-solving classification areas (CRESST model; Appendix G) was provided for students to refer to as they played *Web Earth Online*. The majority of students rarely referred to the example-message document. Students as they been instructed to do created and sent unique messages during game play.

Game-based dialog takes place when players type messages to one another during game play (Table 3). Each message sent by players within *Web Earth Online* was limited to 40 characters including spaces. The researcher maintained a record of all chat log files.

As part of the experimental study, a content analysis was conducted only on the chat dialog that took place during class time. The game developer was available online during each day of the research study to troubleshoot technical issues and to create daily log files of the player dialog and forward them by email to the researcher. The researcher was accessible to participants during game play to answer questions related to game play.

On Day 2 to 8 of the research study, the researcher and teacher provided instruction of the academic content in the instructional unit to students in the comparison groups (55 minutes per day), whereas students in the experimental group played *Web Earth Online* (55 minutes per day).

After the 8-day treatment period, the researcher used 2 additional days (due to rotating schedule where each period does not meet every day) to administer two achievement measures (concept-map construction and traditional multiple-choice measures) and a game satisfaction inventory (Appendix H) and unit satisfaction survey (Appendix I).

Table 3

Samples of Chat Dialog

Type	Chat dialog
Adaptability	i need to bathe ill be right back need food b right bck
Coordination	hurry, it's almost fall go!go!go!
Decision Making	go out and get some food you need some sorry I need body heat
Interpersonal	can u help me build my nest we need more straw
Leadership	play with the babies and shake the nest follow me go out and get food u need some
Communication	Ahhh im out of energy need to mate

Instrumentation

Several instruments were used in the current study. For some of the instruments, an internal consistency reliability was analyzed, and where possible, the survey instruments were modified to reflect a more reliable instrument. In this section, a description of the following instruments is provided: Game Experience Instrument, Traditional Pre- and Posttest Instrument, Game Satisfaction Instrument, Unit Satisfaction Instrument, and the Expert Criterion Concept Map Instrument.

Game-Experience Instrument

This researcher-designed 14-item self-report measured participant's experience with video games and their video game-play habits. A veteran video-game evaluator reviewed the game experience instrument. The instrument was modified based on input from the evaluator that focused on adding one question about player's use of help menus. Participants used *Scantron®* sheets to respond to demographic and game-experience questions.

Traditional Pre- and Posttest Instrument

This researcher-designed 33-item instrument assessed participants' pre- and posttest knowledge of academic content through participants' responses to multiple-choice questions related to the life cycle and the survival needs of the Eastern Bluebird. Participants used *Scantron®* sheets to respond to questions. The *Web Earth Online* game developer and an environmental-science teacher evaluated the pre- and posttest instruments to provide face validity of the game content and the pre- and posttest instruments.

The internal consistency reliability of the original 33-item pretest was poor; Cronbach's coefficient alpha for the pretest was .39, well below the acceptable level of .70. Removal of 14 of these items left a partial test with a Cronbach's coefficient alpha of .59. Although this removal does not increase reliability to an acceptable level, it does improve the reliability greatly. In later research questions, both the original and the amended version of this instrument was tested.

Participants' responses to items in the 33-item multiple-choice traditional pre- and posttest were scored against the researcher-designed answer key. Each item on the pre- and posttests was assigned one point if correct and zero points if incorrect.

Game-Satisfaction Instrument

A researcher-designed 18-item 5-point scale self-report instrument assessed participant's satisfaction with the *Web Earth Online* game. Participants used *Scantron®* sheets to respond to questions related to such areas as usability, graphical interface, and perception of learning. The instrument was administered at the end of the treatment period.

A reliability analysis of the Game Satisfaction Survey was performed. Items that were "negatively" worded were reverse coded prior to computing the average scores. The specific items that were reverse coded were items 7, 8, 14, and 16 (Table 4).

Results indicate that the Game Satisfaction scale did not exhibit adequate internal consistency reliability, as Cronbach's coefficient alpha for all 18 items was lower than .70. Moreover, several items (e.g., items 5) correlated negatively with the scale, suggesting that they should be reverse coded. Some other items had a very low

Table 4

Internal Consistency Reliability of the 18-item Game Satisfaction Survey

Scale Items:	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
GameSatisQ1	61.11	61.61	.67	.51
GameSatisQ2	61.66	61.20	.39	.53
GameSatisQ3	63.34	68.02	-.03	.60
GameSatisQ4	61.58	60.52	.39	.52
GameSatisQ5	63.84	78.14	-.41	.65
GameSatisQ6	63.55	68.58	-.04	.60
GameSatisQ7	61.74	64.36	.20	.56
GameSatisQ8	61.84	62.84	.25	.55
GameSatisQ9	63.42	69.55	-.08	.61
GameSatisQ10	61.32	61.41	.51	.52
GameSatisQ11	61.42	59.76	.53	.51
GameSatisQ12	61.71	61.35	.43	.52
GameSatisQ13	62.26	59.77	.35	.53
GameSatisQ14	61.61	62.08	.31	.54
GameSatisQ15	61.89	60.96	.28	.54
GameSatisQ16	61.58	68.58	-.00	.59
GameSatisQ17	62.11	58.31	.51	.50
GameSatisQ18	63.79	67.20	.04	.58

Note. Cronbach’s Coefficient alpha of full scale = .57

correlation with the scale (e.g., item 16), suggesting they should be removed from the scale. To address this, items (3, 5, 6, 9, 17, and 18) were removed from the scale, and Cronbach’s coefficient alpha was recalculated (Table 5).

After recalculation the *Game Satisfaction Survey* met generally accepted reliability requirements.

Table 5

Internal Consistency Reliability of Modified Game Satisfaction Survey

Scale Items:	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
GameSatisQ1	44.47	60.44	.59	.77
GameSatisQ2	44.98	57.83	.46	.77
GameSatisQ4	45.00	55.89	.50	.76
GameSatisQ7	45.07	57.25	.45	.77
GameSatisQ8	45.22	55.36	.54	.76
GameSatisQ10	44.73	57.31	.57	.76
GameSatisQ11	44.89	58.10	.42	.77
GameSatisQ12	45.38	54.69	.53	.76
GameSatisQ13	46.24	59.11	.21	.80
GameSatisQ14	44.96	56.18	.50	.76
GameSatisQ15	45.44	55.44	.40	.78
GameSatisQ16	44.82	62.45	.20	.79

Note. Cronbach's Coefficient alpha for Full Scale =.79

Unit-Satisfaction Instrument

A researcher-designed 17-item (5 point scale) self-report instrument measured participant's satisfaction with the Eastern Bluebird Unit of Instruction. Participants used *Scantron*® sheets to respond to questions related to such areas as interest in the topic, engagement of activities, and perception of learning. The instrument was administered at the end of the treatment period. Items that were "negatively" worded were reverse coded prior to computing the average scores. The specific items that were reverse coded were items 9, 10, 11, 12, 13, 14, and 17 in the *Instructional Unit Satisfaction Inventory*.

As can be seen in the results (Table 6), the unit satisfaction scale exhibited adequate internal consistency reliability, with Cronbach's Coefficient alpha equal to .84.

Table 6

Internal-Consistency Reliability of Unit Satisfaction Survey

Scale Items:	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
UnitSatisQ1	51.57	117.97	.69	.82
UnitSatisQ2	50.81	119.47	.63	.83
UnitSatisQ3	51.47	129.47	.17	.85
UnitSatisQ4	51.24	119.74	.61	.83
UnitSatisQ5	51.80	125.16	.30	.84
UnitSatisQ6	51.35	118.93	.58	.83
UnitSatisQ7	52.32	118.07	.67	.82
UnitSatisQ8	52.15	136.17	-.06	.86
UnitSatisQ9	51.57	125.25	.30	.84
UnitSatisQ10	51.62	121.75	.41	.84
UnitSatisQ11	51.47	121.40	.42	.84
UnitSatisQ12	51.22	119.88	.55	.83
UnitSatisQ13	51.09	122.85	.40	.84
UnitSatisQ14	51.39	122.90	.39	.84
UnitSatisQ15	51.36	120.49	.50	.83
UnitSatisQ16	51.59	113.42	.74	.82
UnitSatisQ17	50.59	119.31	.59	.83

Note. Cronbach's Coefficient alpha of full scale = .84

Concept Map

The concept maps that students created were relational maps that use linking lines and phrases to explain the relationships between concepts. Students were instructed to construct a concept map that reflected their knowledge about the survival needs of the Eastern Bluebird. The following eight concepts were provided as guide words that students used to build individual concept maps: *diet, communication, appearance, dangers, habitat, courtship, nests,* and *baby bluebirds* as a basis for constructing their maps. Maps were scored against a criterion (expert) map with a total possible score of 280.

Expert-Criterion Concept Map

The expert map was the measure by which student-constructed concept maps were assessed. Student maps were scored against a criterion (expert) concept map based on input from national bluebird experts, including wildlife painters, the *Web Earth Online* game developer, and bluebird conservationists. Each of the experts received via email a skeleton map created by the researcher. The experts were asked to elaborate the researcher-generated map or create a unique map from scratch. Experts created hand-drawn and computer-generated maps. Others provided written narratives indicating map elaborations. The researcher combined the expert information into one consolidated criterion map (Figure 3) and then forwarded the final map to the experts for final input. The expert map used to score student maps was the final version of the expert map.

The concept-map scoring scheme was based on the quality and accuracy of concept map propositions (two concepts and the linking phrase that connects them). A 4-point rubric was used to rate the quality of student-generated propositions within their concept maps (Table 7). The number of propositions in the expert map was 70. The maximum score for a map constructed by students was based on the expert map: the number of propositions multiplied by 4 (all expert-map propositions were scored as excellent). Therefore, the total possible score for student maps was 280.

Interrater Reliability for Scoring Concept Maps

Interrater reliability was established by a team of three educators (the researcher and two teachers from the research school site who used concept maps frequently in their

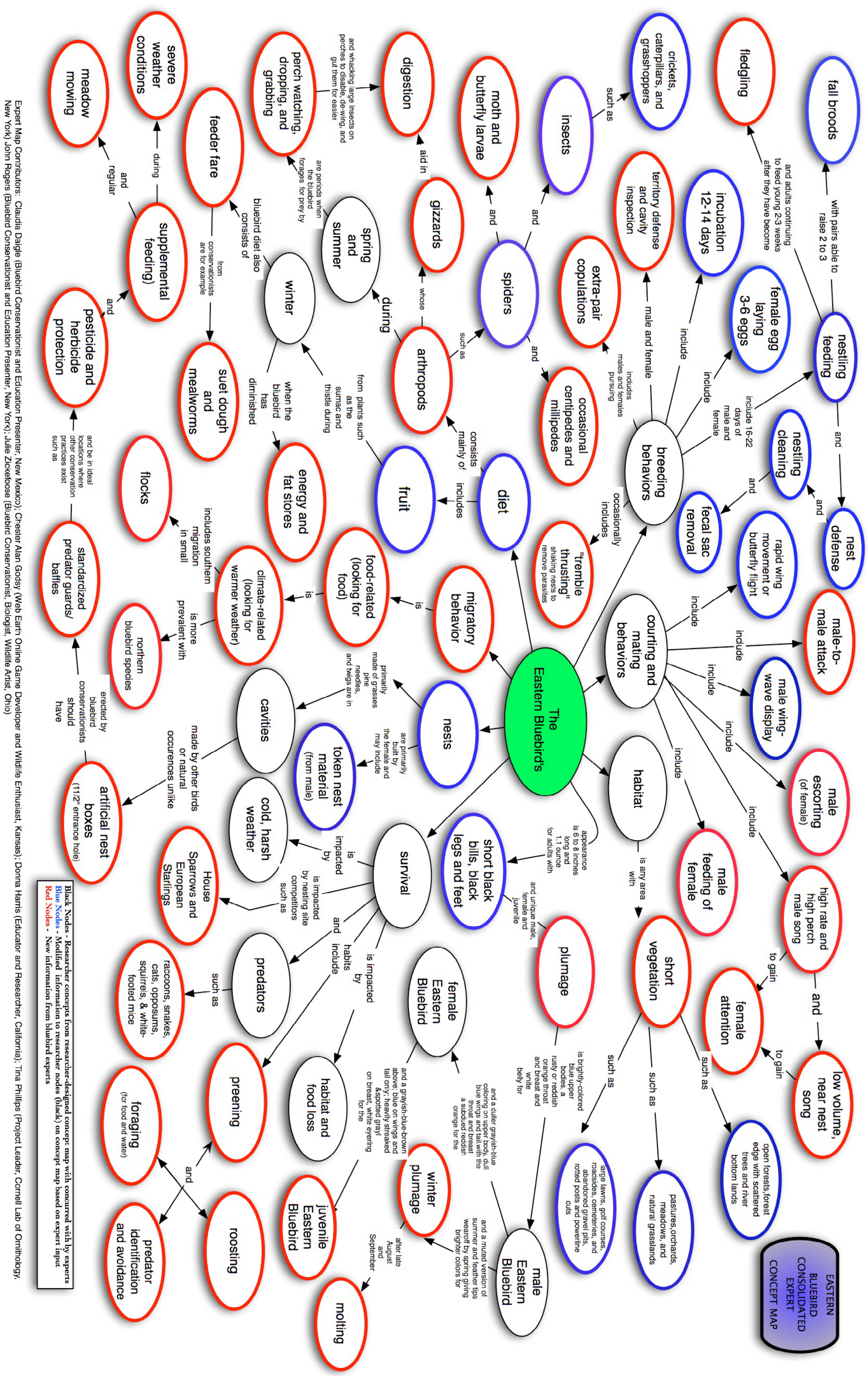

Figure 3. Expert Map

Table 7
Rubric for Scoring Concept-map Propositions

Quality of Proposition	Description
Excellent - 4	Outstanding proposition. Complete and correct. It shows a deep understanding of the relation between the two concepts.
Good - 3	Complete and correct proposition. It shows a good understanding of the relation between the two concepts
Poor - 2	Correct but incomplete proposition. It shows partial understanding of the relation between the two concepts
Very poor - 1	Although accurate, the proposition does not show understanding of the relationship between the two concepts
Inaccurate/invalid – 0	Incorrect proposition

instruction). Each rater individually scored the same10 randomly chosen, student-generated concept maps by evaluating the separate propositions identified on student maps. Each proposition was scored using the 4-point rubric as the guide.

Prior to scoring the 10 maps individually, the three raters scored one concept map jointly to calibrate the rubric scoring process. The team of raters jointly arrived at an agreed upon score for the concept map (based on the 4-point rubric) and then scored the other 10 maps individually (approximately 40 minutes). After the raters had scored 10 maps, the three raters had given the same score for 5 (50%) of the 10 maps. An investigation of the 5 maps that were not scored identically revealed that there was no more than a 3- to 5-point differential. For example, one rater may have given the map a total score of 40, another rater 42, and the other rater 38.

The discrepancies in scores were resolved after discussion among the raters. It was discovered that some of the discrepancies had to do with subtle nuances in how students drew linking lines in their maps (e.g., one linking line with one linking phrase going to two separate concepts). The other discrepancies had to do with facts about bluebirds that the teacher raters were unsure of (e.g., is the score for connecting the concept *habitat* with *forests* and *open forests* worth the same amount of points?). After these discrepancies were clarified by the researcher, all three raters were in 100% agreement on the score for each of the 10 concept maps. Based on these outcomes the scoring scheme was viewed as reliable. Figures 4, 5, and 6, are examples of scored student maps. Figure 4 is a student-constructed map in the researcher comparison group that received a score of 96, the highest student concept-map score.

Qualifications of Researcher

The researcher served as a public-school teacher for 12 years, 9 of which were spent teaching sixth grade and, therefore, has designed standards-based instructional materials in accordance with California Content Standards. The researcher was appointed as a district mentor teacher in technology integration and was the recipient of Intel's *Innovation in Teaching* award for 2 consecutive years because of the researcher's innovative use of technology including computer games, Internet resources, and multimedia tools to support learning.

The researcher's Master's Degree in Education with an emphasis in Instructional Technology and 8-year service in private-school administration as the Director of Curriculum and Instruction extends the researcher experience needed to design instrumentation, instructional materials, utilizing innovative technologies to explore learning benefits.

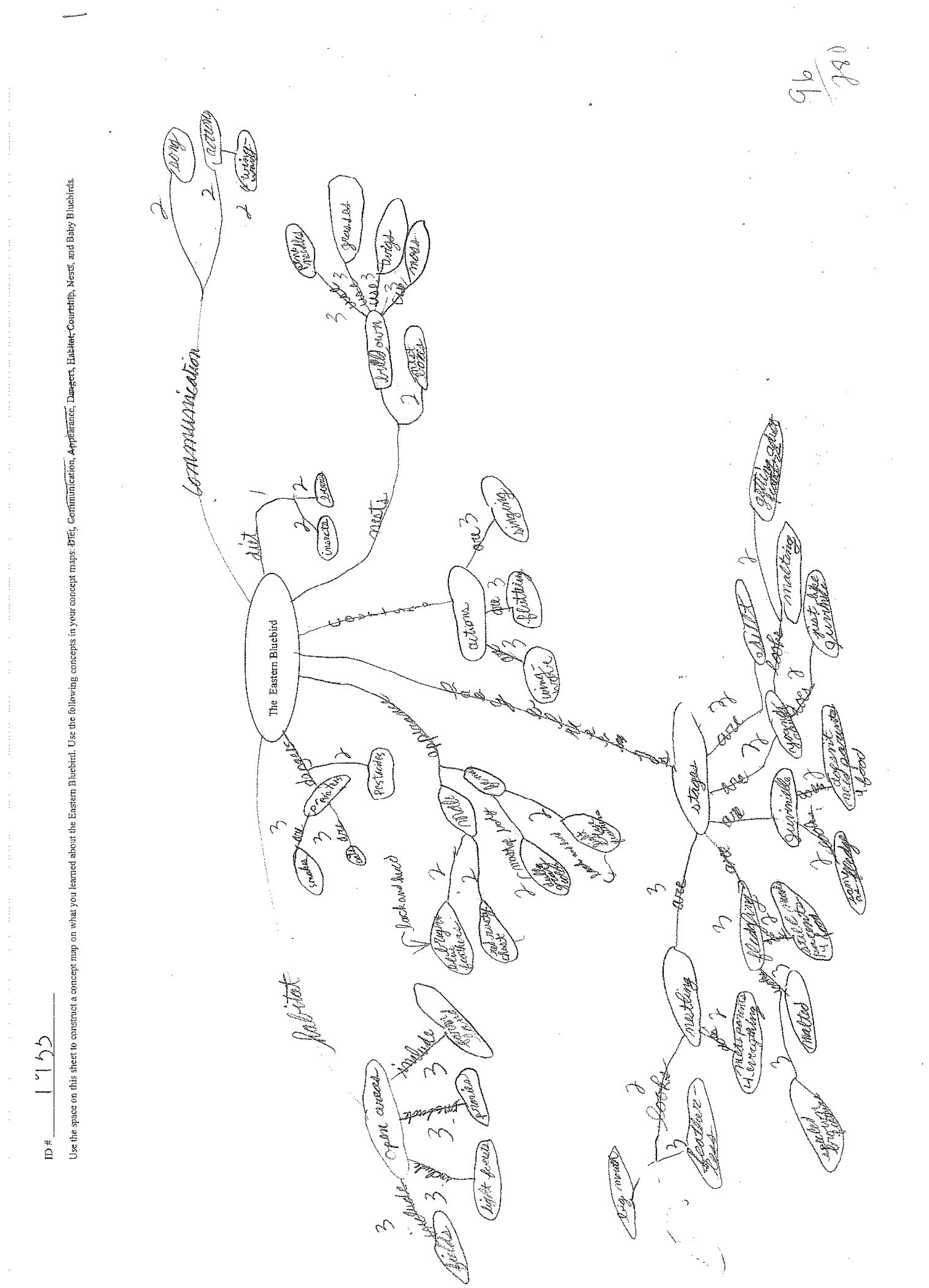

Figure 4. Student-generated concept map with a score of 96

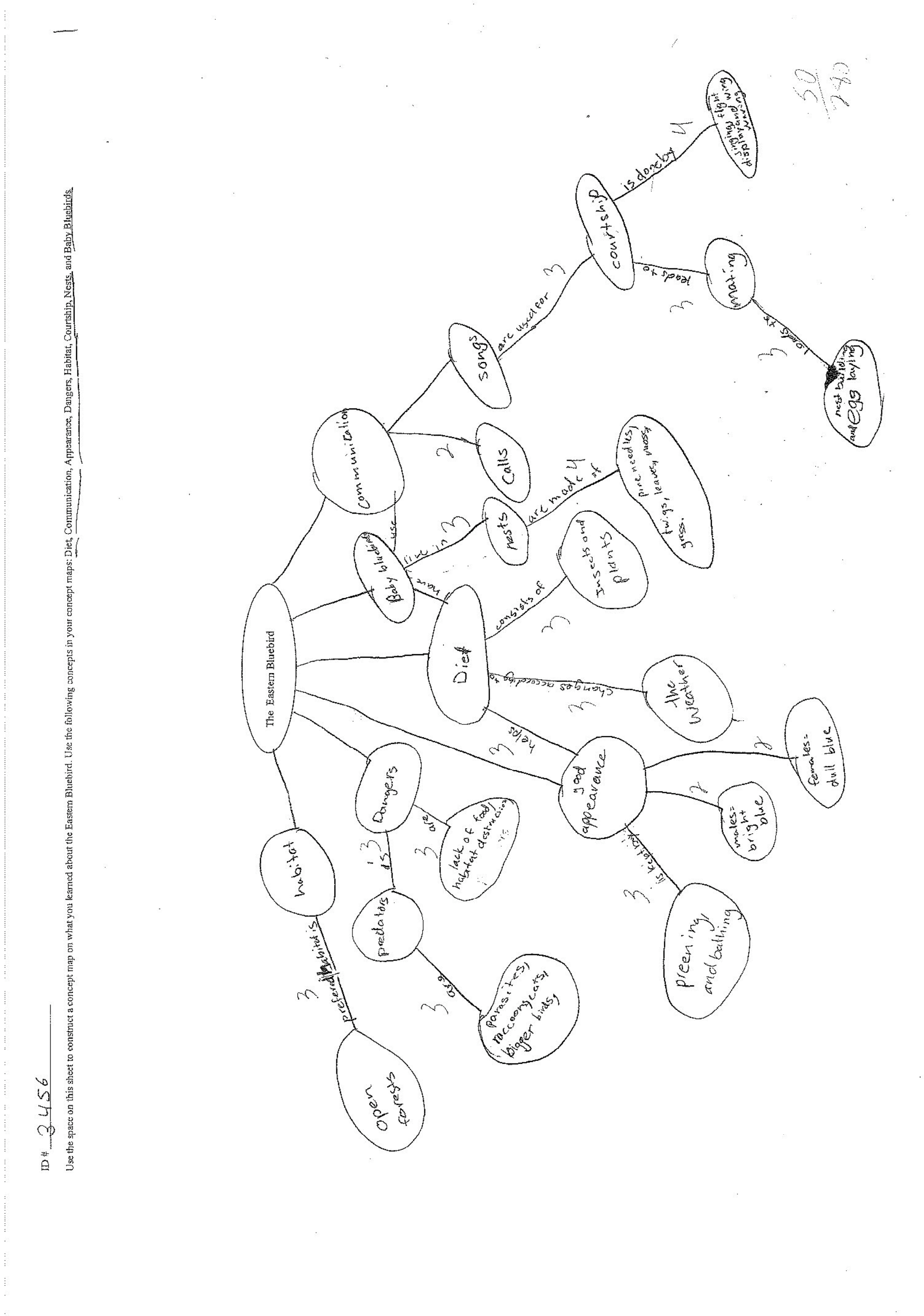

Figure 5. Student-generated concept map with a score of 50

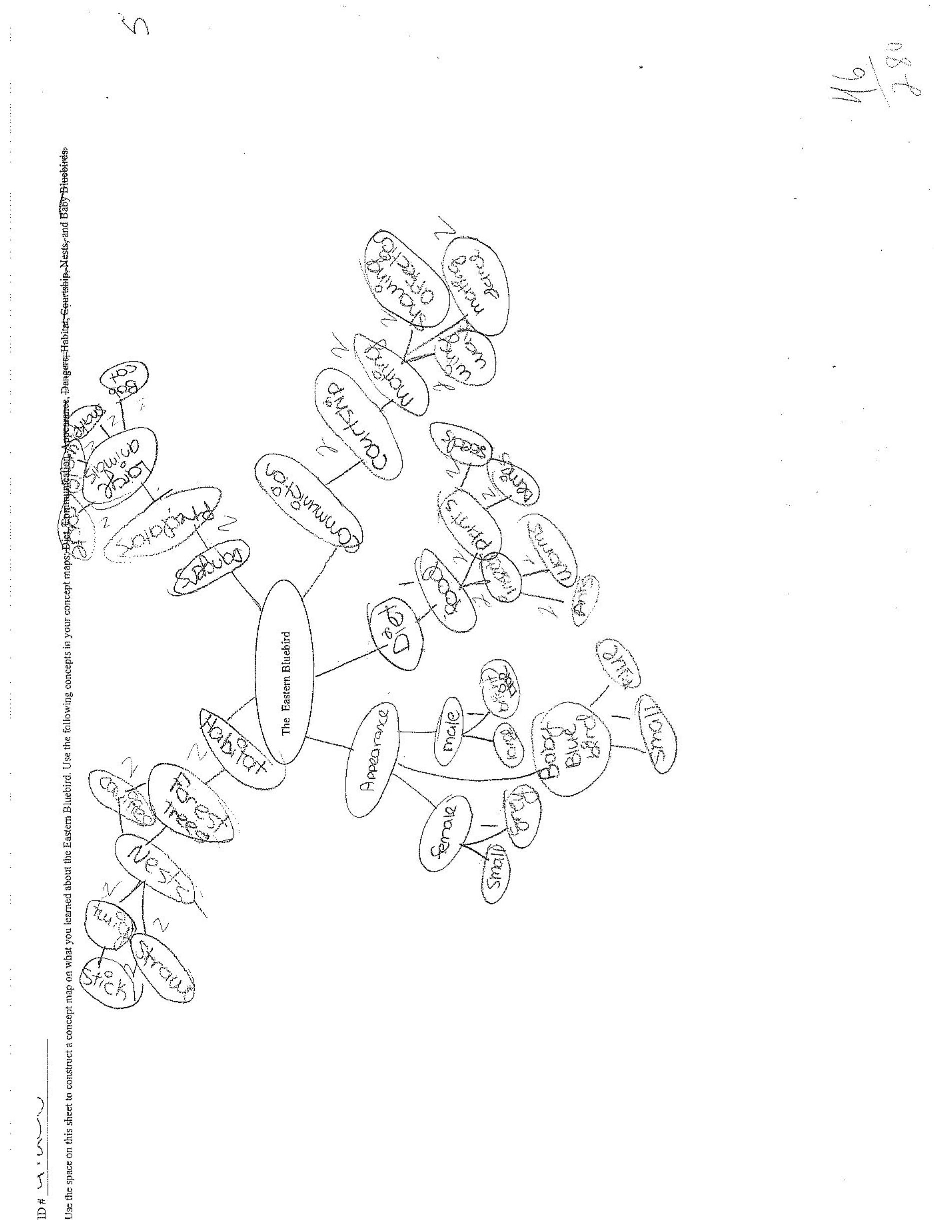

Figure 6. Student-generated concept map with a score of 46

Data Analysis

The research questions and a description of the type of data analysis process that was utilized is as follows:

1. To what extent do MMOG players use collaborative teamwork strategies? A content analysis of the log files of player dialog to assess player collaborative teamwork strategies and their frequencies was performed.

2. Do students in the MMOG group have higher individual scores on the content knowledge unit assessment of bluebird life cycle and survival needs when compared with traditional instruction? A dependent-samples *t* test was performed. The outcome variable in this analysis was the difference between the posttest and the pretest scores. This analysis was followed by a one-way analysis of variance (ANOVA) on the pretest and posttest scores separately. Poc hoc analyses were performed for statistically significant ANOVA. The independent variable for the ANOVA was the three groups.

3. Do students in the MMOG group have higher individual concept-map scores on individual concept-map construction of bluebird life cycle and survival needs when compared with traditional instruction? An ANOVA was used in the concept map scores with the three groups as the independent variable.

4. Is there a relationship between collaborative teamwork-strategy scores for students in the MMOG group and posttest scores? A correlation of frequencies of collaborative problem-solving strategies during game play with posttest scores was utilized to address this question.

5. Is there a relationship between collaborative teamwork-strategy scores for students in the MMOG group and concept map scores? A correlation of frequencies of

collaborative teamwork processes during game play with concept-map scores was utilized to address this question.

6. What is the extent of satisfaction with the MMOG play to present content? An analysis of satisfaction levels from the *Game Satisfaction Inventory* was utilized.

7. What is the extent of satisfaction with the traditional instruction to present content? An analysis of satisfaction levels from the *Unit Satisfaction Inventory* was utilized.

CHAPTER

IV. RESULTS

The main purpose of this study was to investigate the collaborative teamwork processes during Massively Multiplayer Online Game (MMOG) play on individual achievement. An assessment of the types of collaborative strategies the participants used during game play and the performance of individual players after game play on measures of content knowledge (concept-map construction and pretest and posttest) on life science concepts (life cycle and survival needs of various animals) was conducted. Performance of game players was contrasted against the academic achievement performance of the comparison groups receiving traditional instruction.

This chapter presents the descriptive and inferential statistical findings for the study research questions. The research questions focused on participant survey responses, with participants being grouped as comparison groups (R and T; based on whether the group was taught by the researcher or the teacher), and the experimental group who learned using web-based instruction. The research questions tested were as follows:

1. To what extent do MMOG players use collaborative teamwork strategies?

2. Do students in the MMOG group have higher individual scores on the content knowledge unit assessment of bluebird life cycle and survival needs when compared with traditional instruction?

3. Do students in the MMOG group have higher individual concept-map scores on individual concept-map construction of bluebird life cycle and survival needs when compared with traditional instruction?

4. Is there a relationship between collaborative teamwork-strategy scores for

students in the MMOG group and posttest scores?

5. Is there a relationship between collaborative teamwork-strategy scores for students in the MMOG group and concept map scores?

6. What is the extent of satisfaction with the MMOG play to present content?

6. What is the extent of satisfaction with the traditional instruction to present content?

Results for the Research Questions

Research Question 1

For the first research question, which examines the extent MMOG players use collaborative teamwork strategies, a content analysis of the log files of the player dialog to assess player collaborative teamwork strategies, with the student logfile dialogs being grouped into the six collaborative problem-solving components: Adaptability, Coordination, Decision Making, Interpersonal, Leadership and Communication, and their frequencies were performed. The descriptive statistics of the frequencies for the collaborative teamwork strategies, for the experimental group, are presented in Table 8.

The results show that, of the total number of chats logged by the MMOG players (n=5791), only 30% of the chats involved collaboration identified by the components; in particular, the data reveal that collaboration regarding Communication (15%) is most prominent, followed by Leadership (5.8%), Interpersonal (5.5%), and Adaptability (2.5%). Coordination and Decision-making were the least collaborative chats. The remaining 70% of the chats logged were noncollaborative, for example, chats such as

"Hi, who are you." In terms of the research question, the findings show that the MMOG players use collaborative teamwork strategies 30% of the time.

Table 8
Frequencies and Percentages of Collaborative Strategies for MMOG Players

Strategies	Number of Chats	%
Adaptability	145	2.50
Coordination	39	.67
Decision Making	28	.48
Interpersonal	316	5.46
Leadership	338	5.84
Communication	871	15.04
Total Collaboration	1737	30.00
Noncollaboration	4054	70.00

Further investigation into the relationships between the components for the collaborative strategies was conducted using Pearson's product-moment correlation analysis. The results are shown in Table 9. The coefficients range from .10 to .68, which is weak to moderately strong.

Table 9
Pearson's Product-moment Correlation Coefficient Matrix of Collaborative Teamwork Strategies

Dialog Components	1	2	3	4	5	6	7
1. Adaptability	1	-	-	-	-	-	-
2. Coordination	.16	1	-	-	-	-	-
3. Decision Making	.28*	.17	1	-	-	-	-
4. Interpersonal	.34*	.37*	.10	1	-	-	-
5. Leadership	.35*	.41*	.29*	.48*	1	-	-
6. Communication	.57*	.34*	.29*	.65*	.51*	1	-
7. Noncollaboration	.57*	.30*	.20	.55*	.54*	.68*	1

Note. Statistically significant at the .05 level when overall error was controlled

The correlation results reveal that the components are correlated positively; however, Decision Making is not statistically significantly correlated to Interpersonal and Noncollaboration chats. Findings from these results show that there is a high degree of interitem correlation between the collaborative strategies identified for the study from the chat logfiles of the experimental group.

Research Question 2

Research Question 2 asked "Do students in the MMOG group have higher individual scores on the content knowledge unit assessment of bluebird life cycle and survival needs when compared with traditional instruction?" In order to perform this analysis, a dependent-samples *t* test was performed. The outcome variable in this analysis is the difference between the posttest scores and the pretest scores. This analysis was performed on the test of 33 items and on the 17-item test with internal consistency of .59. Table 10 presents the descriptive statistics for the 33 items of the pretest scores, posttest scores, and the difference between pretest and posttest scores.

Table 10
Means and Standard Deviations of Survey Scores

Scores		n	Min	Max	Mean	SD
Pretest Scores	Comparison R	57	7	22	15.54	3.27
	Comparison T	43	6	22	15.21	3.64
	Experimental	59	6	23	14.61	3.35
Posttest Scores						
	Comparison R	57	16	29	22.35	3.36
	Comparison T	40	10	28	20.65	3.51
	Experimental	55	8	27	20.00	3.31
Posttest – Pretest	Comparison R	57	-1	17	6.81	3.18
Scores	Comparison T	40	-3	13	5.53	3.42
	Experimental	55	-4	14	5.29	4.04

Results in Table 10 show that, on average, there was an increase in scores between the pretest and the posttest of 6 points (SD = 3.61) for the overall sample. In particular, the comparison group taught by the researcher showed the greatest improvement with an average of 6.8 (SD = 3.18), with the experimental group showing the least improvement with an average of 5.3 (SD = 4.04). It should be noted that some students had lower scores on the posttest than on the pretest, and some students' scores were much greater than the average of 6 points – almost three times as large.

A dependent-samples t test was performed to investigate whether the pretest-posttest difference in means is statistically significant. Results from this test suggested that there is *a statistically significant difference* in the change between pre- and posttest scores (t = 20.19; df = 151; η^2 = .73) for the whole sample. Further Analysis of Variance (ANOVA) tests showed that the differences between the pretest scores for the groups are not statistically significant (F(2, 156)=1.12); η^2 = .01, which is a weak effect. There is, however, a statistically significant difference between the posttest scores (F(2, 149)=7.16; η^2 = .09. In particular, from post-hoc comparison tests, the scores for the comparison group taught by the researcher are statistically significantly greater than the scores for the experimental group (mean difference = 2.35; standard error = .64; d= .66), with a moderate effect size.

These results imply, therefore, that individuals in the MMOG group did not have greater improvements in scores on the content knowledge unit assessment of bluebird life cycle and survival needs than individuals in the comparison groups.

When using the amended version (17 items) of the survey, results are slightly different. The descriptive statistics are presented in Table 11.

Table 11
Descriptive Statistics of Survey Scores (17-item Survey)

Scores		n	Min	Max	Mean	SD
Pretest Scores						
	Comparison R	57	4	15	9.72	2.90
	Comparison T	43	2	16	9.30	3.19
	Experimental	59	3	14	9.08	2.54
Posttest Scores						
	Comparison R	57	8	16	12.51	1.93
	Comparison T	40	6	16	12.25	2.27
	Experimental	54	6	15	11.56	1.95
Posttest – Pretest Scores						
	Comparison R	57	-3	9	2.79	2.94
	Comparison T	40	-2	9	3.10	2.74
	Experimental	54	-4	9	2.44	2.51

Results in Table 11 show that, on average, there was an increase in scores between the pretest and the posttest of 2.74 points (SD = 2.73) for the overall sample. In particular, the comparison group taught by the teacher showed the greatest improvement with an average of 3.1 (SD = 2.74), with the experimental group showing the least improvement with an average of 2.44 (SD = 2.51).

A dependent-samples t test was performed in order to determine whether the difference in pretest-posttest means is statistically significant. Results from this test suggested that there is *a statistically significant difference* in the change between pre- and posttest scores (t = 12.5; df = 150; η^2 = .48) for the whole sample. Further ANOVA tests showed that the differences between the pretest scores for the groups is not statistically significant (F(2, 156)=.73); η^2 = .01). There is a statistically significant difference, however, between the posttest scores (F(2, 148)=3.20; η^2 = .04). In particular, from post-hoc comparison tests, the scores for the comparison group taught by the researcher are statistically significantly greater than the scores for the experimental group (mean difference = .95; standard error = .38; d= .35), with a small effect size.

These results imply, therefore, that individuals in the MMOG group do not have greater improvements in scores (using the amended version of the test) on the content knowledge unit assessment of bluebird life cycle and survival needs than individuals in the comparison groups.

Research Question 3

The third research question addresses whether students in the MMOG group have higher individual concept-map scores on concept-map labeling of bluebird life cycle and survival needs when compared with traditional instruction. Descriptive statistics for the concept-map scores are presented in Table 12. The maximum possible score is 280. No one is close to this high score. On average, the experimental and researcher-comparison groups have the highest scores.

Table 12
Means and Standard Deviations of Concept-map Scores

Scores		n	Min	Max	Mean	SD
Concept Map	Comparison R	57	8	96	35.19	17.20
	Comparison T	40	9	63	28.85	12.53
	Experimental	55	1	75	32.38	16.30

An ANOVA was conducted, and the results show that there is no statistically significant difference in the concept-map scores between the three groups ($F(2, 149)=1.91$). Therefore, the results imply that there are no statistically significant differences for the three groups on concept-map construction.

Research Question 4

Research question 4 asks, “Is there a relationship between collaborative teamwork-strategy scores for students in the MMOG group and posttest scores?” A correlation of frequencies of collaborative problem-solving strategies during game play with posttest scores was utilized. Log files were analyzed and coded in the six collaborative teamwork areas and noncollaborative. The results of the correlations are presented in Table 13. As the results show, only collaboration chats with regard to Leadership are statistically significantly positively correlated to the posttest scores. This finding suggests that the greater the posttest scores, the more likely the MMOG group collaborated on Leadership issues. All other tests showed that there are no statistically significant relationships. Although not statistically significant, the correlation between posttest scores and noncollaboration chats was stronger than between posttest scores and total collaboration.

Table 13

Pearson Product-moment Correlation Coefficients Between Collaborative Teamwork-strategy and Posttest Scores

Strategies	Pearson’s *r*
Adaptability	-.03
Coordination	.20
Decision Making	.03
Interpersonal	.04
Leadership	.44*
Communication	.13
Total Collaboration	.10
Non-Collaboration	.22

Note: Statistically significant when overall errorate was controlled at .05 level

Research Question 5

The fifth research question addresses whether there a relationship between collaborative teamwork-strategy scores for students in the MMOG group and concept-map scores. A correlation of frequencies of collaborative problem-solving strategies during game play with concept-map scores was utilized. The results in Table 14 show that none of the collaborative problem-solving strategies are statistically significantly correlated to concept-map scores for the MMOG group.

Table 14
Pearson's Product-moment Correlations between Collaborative Teamwork-strategy and Posttest scores

Strategies	Pearson *r*
Adaptability	-.06
Coordination	.13
Decision Making	.10
Interpersonal	.12
Leadership	.14
Communication	-.02
Total Collaboration	.12
Noncollaboration	.11

Research Questions 6 and 7

Research Question 6 asked "What is the extent of satisfaction with the MMOG play to present content?" Research Question 7 asked "What is the extent of satisfaction with the traditional instruction to present content?"

In order to answer these questions, overall satisfaction scores were derived from the responses, to the *Game Satisfaction Inventory* in the experimental group and the *Instructional Unit Satisfaction Inventory* of the comparison groups, by averaging the responses to all items in each of these surveys. All responses were rated on a scale from 1 to 5. After the reverse-coding procedure, higher scores in the responses suggested a higher degree of satisfaction with the game or with the instructional unit. Descriptive statistics for the overall scores are presented in Table 15.

Table 15
Means and Standard Deviations for Game Satisfaction and Unit Satisfaction

Items	n	Min	Max	Mean	SD
Game Satisfaction	56	1.95	5.00	3.00	.50
Unit Satisfaction					
Comparison R	55	1.47	3.94	2.84	.42
Comparison T	40	2.59	3.47	2.98	.24

As can be discerned from this table with 1 indicating strongly disagree and 5 indicating strongly agree, the mean level of satisfaction with the game is 3.0 (SD = 0.50), whereas the mean level of satisfaction with the researcher's instructional unit is 2.84 (SD = .42) and the teacher's instructional unit is 2.98 (SD = .24). These results thus suggest a satisfaction with both units. Additionally, two survey questions – "The unit helped me learn about the bluebird" and "I learned a lot about the survival of the bluebird by playing Web Earth Online" – were analyzed individually, because the are the only two items comparable across the two instruments. To investigate whether any of the test groups indicated that they learned more about the bluebird than others, cross tabulations were obtained on the frequencies to respond to the two above questions. Table 16 shows the frequency of responses (1=Strongly Disagree, 5=Strongly Agree).

This table displays the nonstatistically significant association between the responses for the groups (χ^2 (8) = 14.98). Because there were relatively few participants, and the table above had some cells with expected count less than 5, which is the main assumption required and upon which these chi-square tests are based, response categories

Table 16
Responses to Whether Participants Learned about the Bluebird

	Responses					
Group	1	2	3	4	5	Total
Experimental	3	3	4	15	31	56
Comparison R	3	6	14	17	15	55
Comparison T	0	4	6	10	20	40
Total:	6	13	24	42	66	151

were collapsed. Namely, responses of strongly disagree, disagree, and neutral were encoded as "0" and agree and strongly agree were encoded as "1." The chi-square statistics was recomputed for the compressed response frequencies, as shown in Table 17.

Table 17
Compressed Responses to Whether Participants Learned about the Bluebird

	Responses		
Group	0	1	Total
Experimental	10	46	56
Comparison R	23	32	55
Comparison T	10	30	40
Total	43	108	151

This table does display a statistically significant difference between groups' responses (χ^2 (2) = 8.14). The percentage of responses of agree and strongly agree are 82%, 58%, and 75% for experimental, researcher's comparison, and teacher's comparison, respectively, when the experimental students overwhelmingly indicated they learned about the Bluebird.

In terms of the research questions, these findings show that there is general satisfaction with the MMOG play to present content for the experimental group and general satisfaction with the traditional instruction to present content for the comparison groups.

Additional Analysis

Students in the experimental group were administered a *Game Experience Survey* (14-item; 5 pt scale) to assess their prior experience with digital game play. Because of the literature that suggests students' high skill level with technology tools and their experience with digital games, the researcher investigated the level of prior game play experience for students in the current study. Student familiarity with certain game features such as "chat" that they used in *Web Earth Online* was also investigated. The overall reliability of the *Game Experience Survey* was poor perhaps because of the lack of correlation between individual items. Nevertheless, the researcher was interested in the descriptive statistics from the *Game Experience Survey*.

Fifty-eight of the 59 students in the experimental group completed the survey questions on Day 1 of the study by bubbling in their responses on a Scantron® sheet.

Results in Table 18 indicate that the means of the scores for items in the Game Experience Inventory ranged from a low of 1.74 (for item 15) to a high of 4.39 (item 3). Scores for all items, except 15 and 16, ranged from 1 through 5. Item 15 ranged from 1 through 3, while item 16 ranged from 2 through 3.

Although the Game Experience Survey consisted of 14 items, the responses to five of the 14 questions were of special interest to the researcher to investigate whether findings from the current study are aligned with key assertions (e.g., most students between the age of 11 and 19, play games regularly) found in the popular literature about student game play. The following statements were investigated

Table 18
Descriptive Statistics for Game Experience Inventory Items (N = 58)

	Minimum	Maximum	Mean	Std. Deviation
Q1	1.00	5.00	3.08	1.26
Q2	1.00	5.00	2.75	1.39
Q3	1.00	5.00	4.39	1.18
Q4	1.00	5.00	3.58	1.51
Q5	1.00	5.00	3.15	1.72
Q6	1.00	5.00	2.41	1.19
Q7	1.00	5.00	1.75	1.49
Q8	1.00	5.00	2.43	1.48
Q9	1.00	5.00	2.46	1.71
Q10	1.00	5.00	2.00	1.15
Q11	1.00	5.00	3.98	1.29
Q12	1.00	5.00	3.51	1.18
Q13	1.00	5.00	3.65	1.26
Q14	1.00	5.00	2.58	1.41
Q15	1.00	3.00	1.74	.54
Q16	2.00	3.00	2.43	.49

1. I play video games regularly. On a scale of 1 to 5 with 1 being strongly disagree and 5 being strongly agree, the mean group response was 3.08.

2. I have played an online game where I am a character in a virtual environment. On a scale of 1 to 5 with 1 being strongly disagree and 5 being strongly agree, the mean group response was 3.52.

3. I have used online chat features during game play. On a scale of 1 to 5 with 1 being strongly disagree and 5 being strongly agree, the mean group response was 3.10.

4. I have never played a video game. On a scale of 1 to 5 with 1 being strongly disagree and 5 being strongly agree, the mean group response was 1.72.

5. I am comfortable using computer technology. On a scale of 1 to 5 with 1 being

strongly disagree and 5 being strongly agree, the mean group response was 3.91. This data indicates that in general, the experimental group was adept in the use of the computers, were experienced video game players, and used chat and avatar representation frequently.

Summary

The objective of this study was to investigate the collaborative teamwork processes during Massively Multiplayer Online Game (MMOG) play on individual achievement and to ascertain the types of collaborative strategies used by MMOG users and their relationship with student achievement. Results of the analysis showed that individuals who participated in the experimental group tended to have statistically significant *lower* posttest scores than students in the comparison group taught by the researcher (based on the 33-item test results) or in the comparison group taught by the teacher (based on the more reliable 17-item test results). Although no statistically significant differences were found in the scores from the experimental group, a statistically significant difference between pre- and posttest was found for the whole sample.

Moreover, nonsignificant differences among the three groups in terms of concept-map scores were observed. An analysis of the chat log files of the MMOG participants revealed that only 30% of the chats involved collaboration, with the more common strategies being Communication, Leadership, and Interpersonal. A statistically significant positive correlation was found between usage of Leadership strategies and posttest scores. Findings from correlation results show that there is a high degree of interitem correlation between the collaborative strategies identified for the study from the chat log files of the experimental group.

The percentage of responses of agree and strongly agree that participants learned from the learned from the MMOG and the instructional unit are 82%, 58%, and 75% for experimental, researcher's comparison and teacher's comparison, respectively, with the experimental students overwhelmingly indicated they learned about the Eastern Bluebird.

CHAPTER

V. SUMMARY, DISCUSSION, AND CONCLUSIONS

This chapter provides a summary of the research findings, limitations, key discussion points that surfaced from the research, implications for practice, and future research. Salient conclusions are also drawn.

The objective of this study was to investigate the collaborative teamwork processes during Massively Multiplayer Online Game (MMOG) play on individual achievement and to ascertain the types of collaborative strategies used by MMOG users and their relationship with student achievement.

Summary of Research

To determine the effect of collaborative problem solving during MMOG play on individual life-science posttest and concept-map scores, a quasi-experimental study was conducted with 159 sixth-grade students (66 male and 93 female). The study sample consisted of one experimental group of 59 students and two comparison groups: one researcher-led (57 students) and the other teacher-led (43 students). Participants completed a 33-item content-knowledge test and constructed a concept map on the Eastern Bluebird following MMOG game play (experimental group) and the completion of a traditional instructional unit (comparison groups). In addition, participants completed a Game Experience Survey (experimental group), a Game Satisfaction Survey (experimental group), and a Unit Satisfaction Survey (comparison groups) during the treatment period. The independent variable was groups (MMOG or traditional instruction), and the dependent variables were measures of academic achievement in the form of concept-map and posttest scores, and student satisfaction scores. The research questions were as follows:

1. To what extent do MMOG players use collaborative teamwork strategies? A content analysis of the log files of the player dialog to assess player collaborative teamwork strategies and their frequencies was performed.

2. Do students in the MMOG group have higher individual scores on the content knowledge unit assessment of bluebird life cycle and survival needs when compared with traditional instruction? A dependent samples *t* test was performed. The outcome variable in this analysis was the difference between the posttest and pretest scores. This analysis was followed by a one-way analysis of variance (ANOVA) on the pretest and posttest scores separately. Post hoc analyses were performed for statistically significant ANOVA.

3. Do students in the MMOG group have higher individual concept-map scores on individual concept-map construction of bluebird life cycle and survival needs when compared with traditional instruction? An analysis of variance was used. The three groups served as the independent variable, and the posttest scores were the dependent variables.

4. Is there a relationship between collaborative teamwork-strategy scores for students in the MMOG group and posttest scores? A correlation of frequencies of collaborative problem-solving strategies during game play with posttest scores was utilized to address this question.

5. Is there a relationship between collaborative teamwork-strategy scores for students in the MMOG group and concept map scores? A correlation of frequencies of

collaborative teamwork processes during game play with concept-map scores was utilized to address this question.

6. What is the extent of satisfaction with the MMOG play to present content? An analysis of satisfaction levels from the *Game Satisfaction Inventory* was utilized.

7. What is the extent of satisfaction with the traditional instruction to present content? An analysis of satisfaction levels from the *Unit Satisfaction Inventory* was utilized.

This following sections provide a brief summary of the research findings, the research limitations, research discussion, implications for practice, and future research.

Summary of Findings

Results of the analysis showed that individuals who had participated in the experimental group tended to have statistically significant *lower* posttest scores than students in the comparison group taught by the researcher (based on the 33-item test results) or in the comparison group taught by the teacher (based on the more reliable 17-item test results).

An analysis of the chat log files of the MMOG participants revealed that only 30% of the chats involved collaboration, with the more common strategies being Communication, Leadership, and Interpersonal. All of the results were not statistically significant; however, a statistically significant positive correlation was found between usage of Leadership strategies and posttest scores.

Limitations

There were several limitations of the study that are listed and described in greater detail below. The limitations of the study were (a) the relatively short duration of the treatment period that limited the amount of MMOG total game-play time and game play at one sitting, (b) the inability to control whether students engaged in game play outside of the school-based treatment period, (c) the computer-laboratory setting of the MMOG game play, (d) the amount of time devoted to concept-map instruction, (e) the initial limitation at the beginning of the study to one game world and, consequently, one virtual season, and (f) the researcher coding of the log files.

Persistent games such as MMOGs are games whose actions, activities, and time progressions continue after players have logged off. The game is not limited to one episode of game play that is repeated but rather, players encounter a variety of tasks, challenges, and conquests that differ with each game-play episode. Typical game play is not structured to a preset length of time. During the 415-minute game-play experience during the experimental period, students' bluebird avatars were immersed in their natural habitat and focused their efforts on survival (e.g., maintenance of feathers, foraging for food, building nests, protecting territory). Through researcher observation, point accrual (occurs dynamically during game play), and an assessment of daily student-chat log files, all students demonstrated progress in learning the game. By the end of the study, most bluebirds had been able to mate and raise young. Others were barely able to build suitable nests and maintain basic physical needs. More game-play time would have allowed student expertise to develop and perhaps more rich collaborative interaction.

Flexible scheduling is a strategy that schools employ to support teaching and learning in the middle- and high-school levels (Brown, 2001). One method of flexible scheduling is a rotating schedule to allow students to attend each of their seven classes four times per week at different times during the school day. The benefit to students is that instruction in a particular subject does not always occur at the same time (e.g., mathematics after lunch Monday through Friday). The rotating schedule of the school (daily rotation of only the first four class periods of the day) where the study took place, although beneficial to students, forced a modification of what was originally a 10-day treatment period to an 8-day treatment period.

Once assigned a *Web Earth Online* account, participants could log in to play outside of the game treatment period even though they were instructed by the researcher not to do so. Forty-two percent of students in the experimental group indicated that they played the game outside of the treatment period. As with the majority of MMOGs, these data indicate the high level of engagement that these games provide although the time spent outside of the treatment period for individual students is unknown. Time may have been limited to a few minutes or a few hours; however, with the exception of a few students, during the treatment period the researcher observed that the majority of students were at the same level of play expertise. Because of the comparable levels of student expertise one may surmise that the game play outside of the treatment period for most students was probably for brief periods. Game playing outside of the treatment period may have provided an advantage in the concept map and posttest measures. Given that this MMOG had an explicit learning focus, bluebird survival, the fact that students chose to play outside of class time is an indication that MMOGs can be viable pedagogical tool.

The typical MMOG play is diffuse with player avatars engaging in game play from their personal computers in a location most suitable for them. Players collaborate through in-game chats. In the current study, students sat side-by-side in a computer lab setting; therefore, students had the ability to speak to one another although this practice was strongly discouraged during the treatment period. In order to mediate this concern, students were assigned to play in one of three virtual worlds (groups of 10 students were assigned to three different worlds) and were not advised of the worlds in which their peers were assigned. In addition, each student was provided with a unique screen name that students were asked not to share. Nevertheless, students, by virtue of the close proximity to one another, did engage in whispered conversations at times. It can be assumed that some of the whispered dialog was collaborative and, therefore, was missed because it was not captured in the chat log files.

At the beginning of the study, the game world assignments (10 students per class assigned to World 21, 22, or 23) posed an the unanticipated problem related to the game –based seasons of the year. Each of the 59 students in the two experimental groups originally were assigned to one of three password-protected game worlds (World 21, 22, and 23). The *WebEarth Online* game developer was willing to set up private game worlds for teachers. No other individuals or groups had access to the game space. Each game world progresses through the four seasons as in the real world. The distinction is that in the game world the duration of each season is one real-time clock hour (e.g., in World 21 from 8:00AM to 9:00AM the season is Fall and from 9:00AM to 10:00AM the season is Winter, and so on). The game interface indicates the current game season and the time left in the season when players log on.

An initial limitation was that because the two experimental class periods were scheduled to play the game at the same time every day (the two periods after lunch), the game season was always the same (e.g., always Fall from 1:00PM to 2:00PM each day) for a particular world. Because the class period was less than an hour students remained in the same season for the entire class period. The problem with this scenario is that some of the bluebird avatars were at a distinct disadvantage in terms of survival. If players always had to play during the harsh winter weather when their primary diet (insects) was not as plentiful or in the Fall that was not the mating season, then despite the growing skill levels of players and the collaborative sharing, they would still be limited by their game-world assignment. Because of these limitations, on the third day of the treatment period, the researcher allowed students to log in to any one of the three game worlds because each game world progressed through the seasons during different real-time clock hours. Bluebird avatars under the control of players could move between the three game worlds by simply logging out of one world and logging in to the other. For example, if a player had built successfully a nest and was ready to mate but could not because of the Fall season, they had the option of moving to another game world that was in a different season, then quickly rebuilding a new nest, and mating and raising young before the class period ended.

Due to the time constraints for the experimental study, the amount of time spent on the concept-map instruction was limited. Based on McClure, Sonak, & Suen's (1999) recommendation that college students receive 90 minutes of concept-map instruction and associated guided-practice activities, the 30-minute researcher-designed concept-map instructional module was not sufficient for sixth-grade students.

McClure et al. (1999) contended that ongoing guidance of students through planned learning activities is essential for students to become adept at concept-map construction. An opportunity to compare student-generated maps against teacher and expert maps with ample time to allow for student questions and feedback (especially on relational links of concepts) is another essential component. The results of these focused learning activities not only support student organization and elaboration of course content but also will build concept-mapping skills. The reduced amount of time for instruction may have resulted in the less-comprehensive and poorly-constructed maps of some students. In addition, the limited instruction time may have resulted in the relatively low concept-map scores.

The researcher coded the collaborative dialog of MMOG players into the six collaborative teamwork strategy categories. While the definition of these categories were distinct, during the actual analyses and coding of the chats, it may be argued that individual chats could have been coded into more than one category (e.g. "follow me to get food" could be coded as l*eadership* or *decision-making*). In addition, a case can possibly be made that the categories overlap; therefore, although carefully approached based on the CRESST coding scheme, the reliability of the researcher coding of the log files may be questioned. Fischer and Strijbos (2007) address this limitation in the current study. They contend that methodological guidelines in the use of content analysis and coding to assess collaborative learning are not as straightforward as guidelines for other methods such as questionnaires.

Discussion

The discussion section focuses on the salient points that surfaced through the analysis of log file, concept map, traditional assessment, and survey data as well as researcher observations during the treatment period. Discussion assertions draw from the research literature.

Concept Maps

As noted earlier in the literature review, the integration of concept maps as a metacognitive tool is an effective approach to assist students in building cognitive structures in all domains but especially in science (McClure et al., 1999; Novak, 1990; Rubba & Rye, 1998). There is also evidence that, when concept mapping is integrated into instructional planning and students are given opportunities to use concept maps during learning, they are better able to make sense of science subject matter and progress toward expert knowledge (Abrams et al., 2000; McClure et al., 1999; Rubba & Rye, 1998). Low initial concept-map scores are not atypical when learners are not engaged in ongoing practice of concept-map instruction during learning. In Chung, Herl, and O'Neil's (1999) study, triads constructed concept maps on environmental science concepts at two different times, 7 months apart. No attempt was made to keep the groups intact across the pre- and posttest data collection. Group concept-map means were considerably lower (5.98) than the expert-map score (22.50) for semantic content that have characteristics of the relational concept map.

In the current study, no student concept-map score approached the expert-map score of 280. A score of 96 was the highest score across all groups. Concept-map tasks during the treatment period were limited to basic tasks following the 30-minute instructional period on the first day of the experimental study and the end-of-unit concept-map assessment on the last day of the study. Participant's experience with concept maps had been fill-in concept maps as end-of-chapter textbook activities. They had not been provided explicit instruction on the use of concept maps as learning tools and they had not been taught specific concept-map techniques. The mean concept-map score of 32.50 across all groups may have been improved with additional instructional time on concept-map techniques.

Students in the comparison and experimental groups may have benefited from integration of a series of concept-map tasks throughout the bluebird instructional unit culminating in a final concept-map assessment at the end of the instructional unit. Interim concept-map scores demonstrating progress toward expert knowledge and higher final individual concept-map scores may have resulted with this approach.

Upon close examination of the student-generated concept maps, many contained correct information but lacked a coherent concept-map structure. Rather than constructing maps with nodes containing concepts and linking lines with linking words to form propositions that show relationships between concepts, many students composed fact-based sentences about the Eastern Bluebird and loosely integrated the sentences into the concept map (Figure 7).

Consequently, many students received lower scores on their constructed concept-map propositions based on a relationally based scoring rubric. If the assessment had been a traditional short-answer assessment, one could assume that the mean would have been higher than the concept-map scores based on the quality and accuracy of the *short-answer* responses. Canas and Novak (2006) advised that full sentences should not be incorporated into concept maps because sentences often represent multiple concept-map subsections and propositions. Suggestions for improving student concept-map techniques are provided in research detailed below.

McClure et al. (1999) asserted that students' skills with concept-map techniques directly affect the reliability and validity of concept-map assessment scores. They recommended that students be trained through direct instruction with ample opportunities through guided practice for students to demonstrate their learning of concept-map techniques. In their research, McClure et al. provided 90 minutes of direction instruction to college students (the majority of the time devoted to guided practice). Consequently, students produced maps with score reliabilities as high as .76 on a scale of 0 to 1. It is

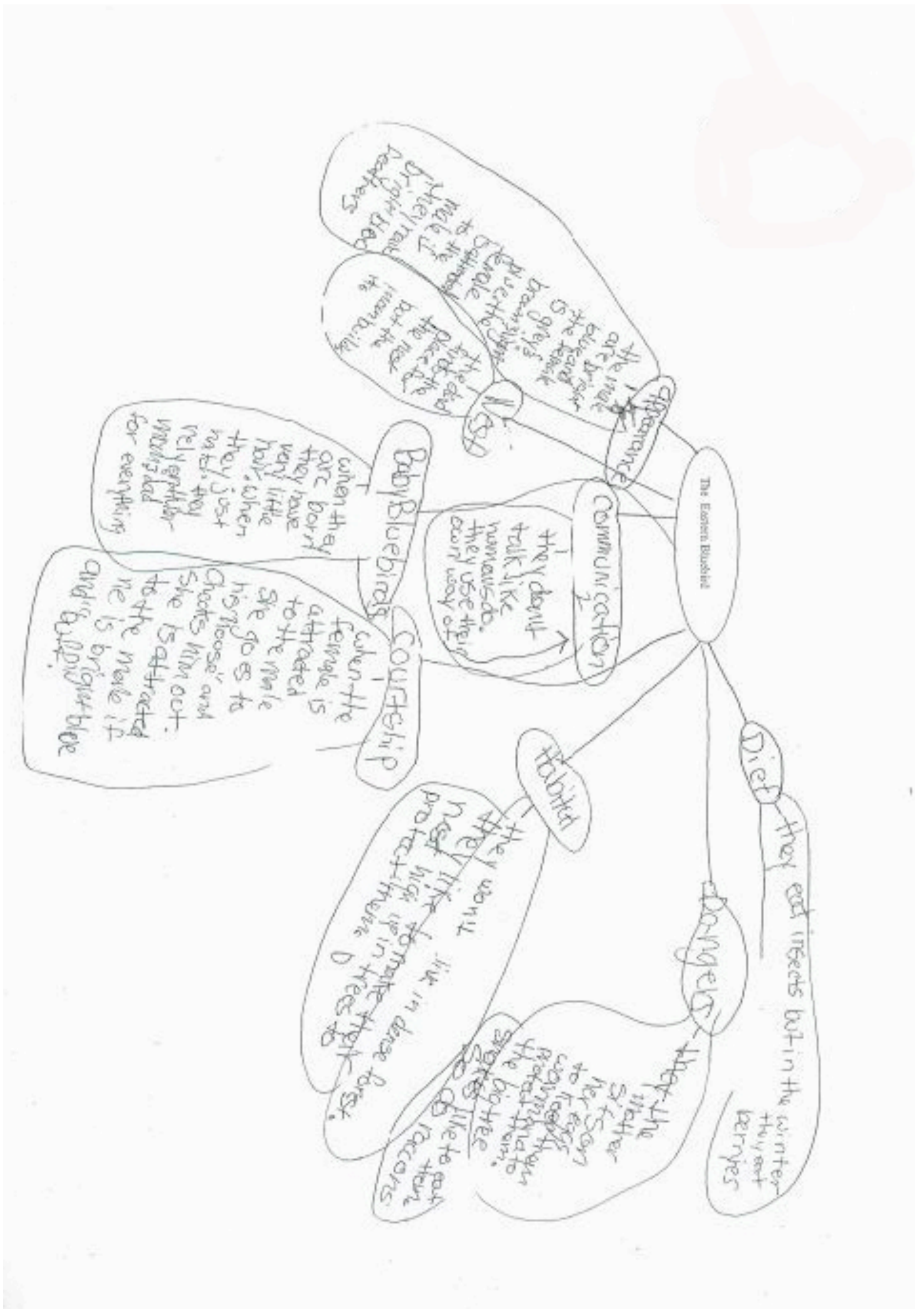

Figure 7. Student-generated sentence-based concept map

expected that college students' higher-level cognitive ability should allow them to grasp concepts much quicker than sixth-grade students; therefore, the instructional time needed to teach concept-map techniques to middle-schoolers should be a longer duration with added learning scaffolds.

The concept-map activity from the current study may be viewed as an unfair assessment for certain learners because some scholars argue that the ability to generate concept maps favors individuals with a particular leaning style (e.g., visual learners). Because of these differences, individuals who are nonvisual learners are believed to be at a disadvantage when tasked with generating concept maps. Canas and Novak (2006) disputed these claims and suggested that the ability to build high-quality concept maps is reflective of the type of school-setting learning practices in which students have been engaged. They asserted that students who are products of rote-mode learning practices, which is typical in many educational settings, have difficulty with concept-map construction. The student performance on the concept-map task in this study may have been impacted by these rote-mode learning practices.

The current study asked students to construct individually concept maps following computer-mediated learning. Research (Basque & Pudelko, 2004; Bosung, Chia-chi, & I-Chun, 2005) indicates that collaborative concept mapping as an instructional strategy during or following computer-mediated instruction results in positive cognitive and affective outcomes as students benefit from the knowledge of others. The collaborative concept-mapping tasks in previous research typically involved dyads or triads who were instructed to construct collaboratively concept maps to summarize learning content from web-based sources. In the current study, students were not grouped in dyads or triads during game play. They were encouraged to collaborate to enhance their bluebird avatars' chances of survival but were not assigned to teams; therefore, the concept-map task in the current study was an independent task to assess individual academic performance. Furthermore, researchers suggested that individual concept-map creation is an important measure of achievement (Adesope & Nesbit, 2006; Gilbert & Greene, 2002; Kommers & Stoyanova, 2002).

MMOGs and Log Files

Cakir, Xhafa, and Zemel (2007) suggested that collaborative problem solving within computer-mediated environments is interactive and learners are able to engage in multiple problem-solving activities at once. The interactive nature of game play was apparent in the current study as well as the ability to engage in concurrent conversations and problems-solving activities. Collaborative learning began during the first-class period of game play as evidenced by the log file data; however, a considerable amount of the initial chat dialog consisted of greetings or questions such as "Who is player …" " Hi, who are you?" and "Whatz cracken lacken?" Avatar-status comments such as "I just died" and "I'm dirty" were quite frequent as well. These comments were coded as noncollaborative. Gradually, as players became more familiar with the game interface, dialog that was more collaborative emerged as players began to ask questions such as, "How do you build a nest?" and "Where do you find food?" and "How do you drink?"

The researcher also observed many incidences of bluebird avatars intentionally taking the nesting site of other bluebirds and stealing the gathered food supplies. In some ways, this became a game within a game as players were forced to contend with the game-based predators as well as "peer predators" not unlike the authentic habitat of bluebirds. Players found the intended purpose of the game (to survive as a bluebird and raise young) to be interesting and engaging, but they also found it equally engaging to outsmart their middle-school counterparts.

As participants developed higher level skills, teambuilding began as partners and trios worked together to build nests, breed, and raise young (e.g., "You stay here. I'll go get food.") The researcher also noted that the organic teaming happened more with the female participants, whereas, males tended to work alone or as mentioned earlier to seize other player's nests. Males also were more apt to approach a female bluebird avatar for mating, whereas, the female bluebird avatars sought nonplayer controlled avatars (NPCs). Game developers often include computer-controlled NPCs in game worlds to provide additional action with characters other than "real-people" characters. In Web Earth Online, male and female bluebird avatars had the option of mating and raising young with NPCs. They were able to recognize NPCs by the dash (-) that preceded their ID numbers.

Although the content analysis revealed that only 30% of the chats in the current study were coded as collaborative teamwork dialog, other recent research (Cakir et al., 2007) that analyzed chat-based problem solving of middle- and high-school students found that only 56.7% of students postings reflected problem solving for an explicit nongame-based problem-solving task. Students had been tasked with working collaboratively (in a computer-mediated environment) in groups of three to five to solve mathematics problems that had been posted online. In Chung et al.'s (1999) study that sought to refine their previous work, collaborative teamwork processes (CRESST Model) were assessed during collaborative (triads) computer-based knowledge mapping. The triads' task was to construct a computer-based concept map based on environmental science content. In Chung, Herl, et al.'s study, student dialog was constrained because it was limited to a list of predefined messages. Analysis of the chat dialog indicated that 69% of the dialog was coded as collaborative and 31% as noncollaborative (e.g., yes and no messages and messages indicating that a message was sent in error). Furthermore, the overall analysis in Chung, Herl et al.'s study indicated that the less that participants used messages, the higher they performed on knowledge mapping tasks. The researchers conjectured that the low number of messages was due to the restrictive nature of the chats that were limited to 35 predefined messages.

Of interest to the researcher in relation to the current study that did not impose restrictions on chat dialogue while playing *Web Earth Online*, is that it is assumed that an explicit task (e.g., mathematics problem solving and knowledge mapping discussed above) would result in a high percentage of collaborative problem-solving chats, but it did not in either of the above cases. In a challenging MMOG environment where no explicit problem-solving directives are given, it may be that low quantities of collaborative dialog may be appropriate.

Satisfaction Surveys

Even though students indicated a mild to moderate satisfaction for the game and instructional unit (M= 3.0 and 2.84, respectively on a 5-point scale), it is important to note that the satisfaction surveys (Appendices H and I) covered a broad spectrum of questions rather than solely focusing on students' contentment and happiness with the game or instructional unit.

In regard to the MMOG, there were indications suggesting that the game was engaging and in-game learning challenges were motivating. Students returned to the library to engage in after-school game play as reported by the media specialist (e.g., examples of comments made to library personnel were " I want to keep practicing building my nest." "I was just about to get a mate when class ended." "I want to make sure that my babies don't die.") In addition, at least 4 students created home accounts for the game as indicated by nonresearcher-created IDs and accounts in the game worlds. Evening chat files that appeared in the restricted experimental game-world log files were evidence of game play outside of the experimental period.

Another indication of game satisfaction was that more than half of the students in each of the experimental groups shortened their lunch period (the experimental groups always met each day immediately after lunch) and lined up outside of the media center requesting permission to enter the computer laboratory to begin game play prior to the beginning of class.

The regular science teacher of one of the comparison groups observed that several students who progressed to expert-practitioner level in the MMOG had been unmotivated (failed to complete assignments, inattentive in class, academically underperforming) students during the regular science instruction prior to the experimental study. One student in particular who rarely completed homework assignments successfully fledged two bluebird broods the second evening after being introduced to the MMOG. Based on input from the game developer, a minimum of 3 to 5 hours is needed to accomplish this task. During the experimental period, the researcher observed that this student actively was engaged in the learning process and was highly proficient in the skills needed to progress through the game. Enhanced student motivation and problem solving through

MMOG play is consistent with the findings of researchers (Black, Boyer, Dipietro, & Ferdig, 2007; Braswell & Childress, 2006).

Ninety-five percent of players responded to the question, "I liked playing the *WebEarth Online* game" with a 4, agree and 5, strongly agree (17% for agree and 78% for strongly agree).

Thirty-nine percent of students in the researcher-taught comparison group responded to the statement, " Overall, I would rate the content of this unit as very good" with a 4 or 5 indicating agree or strongly agree, respectively, whereas 40% of the students in the teacher-led comparison group responded with a 4 or 5. Given that the question asked whether the unit content was "very good" rather than "good" or "satisfactory," the overall responses can be viewed as favorable for the unit content. The unit satisfaction mean of 2.98 (SD = .24) reflecting more homogeneous responses in the teacher-lead group as opposed to a mean of 2.84 (SD = .42) in the researcher-led group may have been related to students' higher level of comfort with their regular science teacher. The researcher had no previous instructional interaction with students prior to the experimental period. Following the research period, the science teacher communicated to the researcher that students (in comparison groups) expressed interest in obtaining many of the resources (books, quicktime movies, music, and Internet resources) from the instructional unit.

An additional discussion point is the contention (Rice, 2007) that the use of traditional assessments, such as the multiple-choice assessment in the current study, may not be appropriate for assessing learning in a MMOG. Assessment of learning using concept maps may be a better tool based on the experimental group's higher means than one of the comparison groups on the concept-map task.

A concluding discussion point responds to the lack of statistically significant findings in favor of the experimental group. The researcher-designed unit utilized for the comparison-group instruction incorporated engaging technology resources and activities (e.g., quicktime movies of bluebird life-cycle events, audio bytes of bluebird song, highly graphical powerpoint resources, interactive web activities, role play, nest building project, collaborative research). These comparison-group instructional elements may not be viewed as "traditional" instruction ("lecture, notetaking, paper-and-pencil activities). The assertion may be made that students in the comparison (traditional instruction) and experimental (MMOG instruction) groups engaged in equally rich learning experiences that minimized learning discrimination.

Furthermore, a claim can be made that the rich learning experiences in the comparison groups provided a situated-learning environment (authentic context, authentic activities, authentic assessment, expert modeling, and situated mentoring) that was very similar to the experiences of students in the experimental groups. Based on the similarity of experiences, the conclusion can be drawn that the results of the data in this study underscore the contention of many educators that instructional quality is anchored in connecting learners within situated-learning contexts, and that these contexts can be created through a variety of methods (e.g. game-based or rich face-to-face multimodal approaches).

The role of the teacher should be adapted to support the varied learning contexts. In this study, the researcher's role in the experimental group was that of facilitator and support as students struggled first with the mechanics of learning the game interface and later then with the decisions they needed to make to ensure survival. In the comparison group, the role of the instructor differed in that the activities were more teacher-guided, but with many opportunities for student-initiated through small group activities

Implication for Practice

It is not unusual for MMOGs to have hundreds or thousands of players engaged in game play at once. This large number can be disconcerting for teachers and parents who are concerned about the dangers of online predators that are often publicized in the media. The Serious Game Initiative led by individuals in academia encourages game developers to design games for education and other sectors that are safe spaces, pedagogically sound, and attuned to the needs of 21st Century learners (Annetta, Bohr, Laird, Murray, & Park, 2006; Sawyer, 2007). In the current study, the Web Earth Online game developer created password-protected game worlds specifically for students in the experimental study. This service is available for any entity for a nominal fee. The ongoing challenge for educators is the question of how to choose appropriately games such as MMOGs for classroom use and how to fit them into the curriculum.

Educators criticize game-based learning (Rice, 2007; Royle, 2008) because there is not enough concrete learning that teachers can tie to the curriculum, the games are long, and do not have specific learning outcomes. Games designed to educate are criticized equally because they do not engage students and do not provide the immersive experience to which students are accustomed. Royle contended that the approach of “teacherizing” commercial or designed games by modifying game content through the addition of curricular content and performance objectives is typical. This "teacherization" of games often results in a diluted game experience that demotivates students.

According to Royle (2008), the solution to this dilemma are games with a problem-based approach that are pedagogically sound and provide the entertainment level that is expected within the gaming culture. The necessary elements of the game would be authentic problems to solve (that naturally and logically flow from the game narrative), believable characterization (player's role is credible), a game structure and narrative that provide purpose, embedded jut-in-time game supports, as well as player support. These important elements are evident in the MMOG utilized in the current study.

The above discussion offers guidance into how to choose games, but educators often grapple with the question of how to integrate these type of games into the parameters of a typical school day. Rice (2007) advised educators to consider how meaningful game experiences can be integrated into learning activities that have flexible time constraints such as after school and summer schedules. Within the typical bell schedule, game experiences need to be parsed analogous to the way an English teacher partitions a novel. The identification of specific learning objectives (these may or may not be articulated to students) for each session of game play should be identified. In the first day of game play in the current study, the researcher's unstated objective was for each player to be familiar with the game features (e.g., how to move around in the game environment, what to click on to accomplish tasks, how to communicate with other players). Chunking game experiences into 40- to 50-minute blocks with clear objectives is a method that has been successful in classrooms. Another suggestion is for educators to find and utilize games that have a less complex interface and a narrow focus that allow for a simpler partitioning of game play. Web Earth Online also meets these criteria. The interface is not complex, and, although it is not unusual for players to immersive themselves in game play for several hours at a time, the game can easily be chunked into meaningful learning experiences.

Teachers also should consider games as a teaching method for flexible grouping. All students do not need to be engaged in game play at the same time, eliminating the need for a one-to-one computer-to-student ratio. Games can extend direct instruction by allowing student to apply their learning in practical, reality-based experiences.

Meaningful learning experiences especially are important for middle-school students in science. Research (Collins, Osborne, & Simon, 2003; Simpson & Oliver, 1985; Snead & Snead, 2004) has shown that middle-school student's interest in science peaks before ninth grade. Middle-grade science is viewed as the gateway for science courses in high school, but there is evidence of a dramatic decline in interest and academic performance in science after fifth and sixth grade. The research literature suggests that interest is linked to the quality of experience with the subject matter (Collins et al., 2003). The integration of games such as MMOGs are tools for creating quality science experiences, student interest, and academic achievement as is evidenced by the ecology-based game in the current study.

The instructional use of concept maps as a way of measuring the knowledge structure of middle-school students and to assist them in connecting new knowledge to prior knowledge is a common strategy utilized in science classrooms to raise the levels of science achievement (Snead & Snead, 2004). Teachers are encouraged to use concept maps to assess prior knowledge. According to Ausubel (1968), misconceptions and alternative conceptions greatly impact learning. Because of the persistency of the influence of perceptions on conceptual change, it is important for teachers to employ strategies that disclose the misconceptions.

Teachers should also use concept maps as an integral part of instructional planning in the form of expert maps to identify learning targets. In the current study, an expert-map was constructed to assess student-generated concept maps at the end of a unit of study. Teachers can create expert concept maps at the beginning of units of instruction to guide learning. With the formulation of good scoring techniques, these expert maps are good discriminators of novice and expert knowledge (Chung, Herl, et al., 1999).

A critical component of the use of concept maps is that teachers and students receive adequate training on concept-mapping techniques and that there are systematic opportunities for student practice with concept-map construction with timely feedback provided (McClure et al., 1999).

The open-ended, inquiry-based learning that technology, such as MMOGs, afford benefit from concept maps as instructional and assessment tools. Student use of concept maps to convey their knowledge allows latitude that is not possible with traditional close-ended assessments.

Future Research

The following section provides recommendations for future research that have surfaced from the current study. MMOG play and the integration of virtual environments continues to be an emerging theme in education (Egenfeldt-Nielsen, 2007; Feldon & Kafal, 2007; Rice, 2007). The current study provides a method for introducing an MMOG into the instructional program that is generalizable to other academic settings.

Consistent with finding from other studies (Baker, O'Neil, & Wainess, 2005; Black et al., 2007; Halverson, 2005), the current research demonstrated that game play is engaging and students are motivated to play and learning happens. Further investigation is still needed in regard to the use of MMOGs for instructional purposes, concept maps as a mechanism to assess learning in MMOG play, and the analysis of player dialogue to assess learning.

Because of the emphasis to raise interest levels in science in the middle-school grades (Snead & Snead, 2004), games may serve as the needed boost to balance the diverse levels of motivation to learn science. The current study indicated that students liked the game and were motivated to engage in the game-play activities. The focus of future research should be the effect of games on student motivation to learn science. Several science-based MMOGs and video games currently exist such as *River City*, *Whyville*, and a recent release called *Immune Attack* that introduces basic concepts of human immunology. If playing games such as these and others will assist students in meeting learning objectives and engage and motivate as well, then future study is merited.

Along those lines of research, it would be important to investigate in future research the specific game elements that peak student interest in science and other disciplines. Specifically, what are the features that are most appealing to players? Theorists suggested that the key elements in maintaining player interest and motivation are the built-in game-based challenges that are experience and problem based, engaging, and exploratory, within a community of collaborative support (Gee, 2004; Ritterfeld & Weber, 2006; Squire, 2005; Steinkuehler, 2006). It may be assumed that these key elements can only be found in high-cost commercial games with powerful game engines that render realistic 3D-graphics and streaming sound; however, this was not he case in the current study. In the current study, once students became accustomed to the browser-based interface of the *Web Earth Online* MMOG that lacked the “bells and whistles” of most commercial games, they were engaged as equally as students playing games with a more sophisticated game interface. If the game elements that Web Earth Online include are sufficient, then there may be more cost-effective MMOG choices such as Web Earth Online for educators.

Egenfeldt-Nielsen (2007) conducted an overview of 21 quantitative studies (studies dated from 1981 to 2006) on the educational potential of computer games. Egenfeldt-Nielsen noted a major weakness in the majority of the studies – no comparison groups utilizing other teaching methods as the computer games were studied. Referred to by Egenfeldt as “one-shot” studies, these studies fail to provide educators with the needed information to assess adequately whether the integration of games is worth the time and effort to integrate into the instructional program. The current study addressed one of Egenfeldt-Nielsen’s concerns because it consisted of two comparison groups and an experimental group; however, future research efforts investigating achievement from MMOG play as compared with traditional instruction should consist of longer treatment periods.

An additional question worthy of investigation is the impact of classroom MMOG play. A typical MMOG engages hundreds or thousands of simultaneous players. MMOG populations are diverse in terms of gender, ethnicity, and age. Because MMOG game servers are located in a variety of geographic locations, players can engage in game play from anywhere in the nation or world. In the current study, the player game world was a private password–protected world designated for study participants only. If classroom teachers create these “less-authentic” MMOG worlds a consideration for future research is whether the integrity of these rich communities of practice, which are the hallmark of MMOG play, can still be preserved.

Rice (2007) questioned whether the action-oriented learning afforded in virtual worlds translates into higher achievement in text-based high-stakes tests. This question deserves consideration in future research. In addition, alternative assessments, such as concept maps utilized in the current study, should be further researched as a tool for assessing the learning that takes place in a MMOG.

Research suggests that player identification with avatars and the ability to customize avatar appearance is considered to be central to virtual-world learning experiences (Feldon & Kafal, 2007). In *Web Earth Online*, players did not have the ability to manipulate the avatar appearance. Each player was assigned to be a male or female Eastern Bluebird based on players’ real-world gender. The physical appearance of each gender, as well as the appearance of other animals in the habitat, was a true-to-life depiction. Further research is needed to investigate what type of game-based learning experience benefits more from the ability to customize avatars because this ability did not appear to be central to the learning experience in the current study.

Because communities of practice within MMOG play overlap with real-life professional communities of practice (Delwich, 2006; Ducheneaut & Moore, 2005; Galarneau, 2005), more research attention should be given in examining the type of learning that results from the mutually beneficial relationship between the two worlds.

An examination of this relationship may provide the needed focus and connections to in-game and real-life learning experiences. Delwich contended that student reflection on the similarities and differences between their experiences and processes in the virtual and real-worlds provides a meta-level awareness of their own learning. For example, in the current study, students learned through game play and interaction with other players that egg laying and simultaneously caring for themselves and their hatchlings took focused effort. Bird conservationists from the real-world community of practice extend this learning by supplementing the in-game experience with real-world experiences in conservation practices that impact egg laying and caring for hatchlings. Student self-assessment of what they learned will assist them in understanding their individual learning processes.

Research supports the benefits of collaborative concept mapping (Basque & Pudelko, 2004; Bosung et al., 2005). Positive students outcomes result in the collaborative concept mapping during or following computer-mediated instruction as learners combine their knowledge to achieve the concept-mapping task. The research on online construction of concept maps typically has focused on dyads or triads working at a distance collaboratively to construct concept maps based on online academic content. The current study focused on individual construction of concept maps following game play due to the emphasis on individual achievement. Future research also should focus on the academic benefits of collaborative concept mapping following game play.

An intriguing line of research is the investigation in how concept maps can be used as a mechanism to discover the collective and divergent learning that takes place in virtual worlds. In addition to chat dialogs to assess learning, as in the current study, an exploration of learning by integrating in-game construction of concept maps should be investigated. The collaborative construction of in-game concept maps as just-in-time learning scaffolds may assist in understanding student knowledge structures. This line of research would support Fischer and Strijbos's (2007) appeal to further explore the crucial role and influences of context (e.g., a MMOG) in the analysis of collaborative learning.

Technology-based solutions to aid in the construction of concept maps and motivation for learning are tools such as *Inspiration* and *CMAP* (Canas & Novak, 2006). For some students, the ability to construct maps using technology tools provides needed scaffolding in defining a concept-map structure. Other tools such as *Pathfinder* assist teachers in automating the scoring of concept maps eliminating concern for the time needed to score concept maps (Clariana & Taricani, 2006). Given that the use of concept maps as instructional and teaching aids continues to escalate, additional research that compares teacher and student use of technology-based concept map tools with traditional mechanisms would offer guidance to teachers and learners as to the overall of effectiveness of both.

The interactive nature of collaborative problem solving should be further examined. In the current study, the content analysis, for the most part focused on quantity of chats. The examination of chat logs that focus on the quantity and the quality of collaborative dialog to better assess what leads to higher individual achievement should be investigated in future research. Stahl and Strijbos (2007) suggested other coding schemes that evaluate longer portions of dialog called chat sequences. In addition, Fischer and Strijbos (2007) suggest that as collaborative learning is studied that more attention should be given to the inherent problems related to studying collaboration.

Fischer and Stribjos assert that collaborative learning is a multidisciplinary field that utilizes a broad spectrum of research methodologies to study collaboration. They suggest that a concerted effort be made to identify appropriate methods that incorporate methodological standards.

In the current study, a content analysis of all chat dialog was conducted. The researcher noted that substantive dialog (more collaborative dialog) increased over time. The first day of game play consisted of a large percentage of greetings and other noncollaborative dialog due to the students' need to acclimate to the game world and because of the social nature of the participants (middle-schoolers). It may have been beneficial to exclude the first day of dialog from the coded analysis because of the aforementioned nature of the majority of the dialog. Future research should investigate whether the substantive dialog increases over time is a phenomenon that is consistent with other learners (e.g., high-school students, adult learners).

Conclusion

In conclusion, the educational use of video games, specifically MMOGs, can be a viable pedagogical strategy. Many questions that educational policymakers, administrators, classroom teachers and parents have raised about the benefits of this 21st Century technology tool were considered in the current study. This current study was important for seven reasons:

1. Empirical research on the type of collaborative interactions and the cognitive benefits of video game play, specifically MMOGs is sparse.

2. Results from the study indicated that the *Web Earth Online* MMOG designed with specific ecology-based learning content was engaging and motivating for students.

3. Results from the study indicated that learning growth occurred with traditional and MMOG-based instruction.

4. Although no statistically significant differences were found in the scores from the experimental group, a statistically significant difference between pre- and posttest was found for the whole sample.

5. Results from the study revealed a statistically significant positive correlation between usage of Leadership strategies and posttest scores.

6. Results from the study indicated that concept maps are appropriate instruments to measure learning in a MMOG.

7. Many practical concerns expressed by educators who are considering the integration of MMOGs were addressed.

The quasi-experimental design (convenience samples) of the current study serves as a model for educators wishing to replicate the research utilizing the same or other MMOGs. A theoretical foundation for understanding the learning affordances of MMOG play and the communities of practice that form and extend to the real-world communities of practice was provided. A discussion of the benefit of concept maps to support teaching and learning as well as techniques for training and scoring maps was proposed. The use of concept maps as an alternative assessment tool for measuring learning in a MMOG was advanced so that educational practitioners will discover other learning outcomes during and after game play.

The reliability of two survey instruments (Game and Unit Satisfaction) in the current study meet the generally accepted reliability guidelines. Educators will be able to refine and utilize these instruments to investigate student perceptions about learning and satisfaction levels from traditional instruction as well MMOG play.

The seven research questions posed at the beginning of the study sought to investigate the collaborative teamwork processes during MMOG play on individual achievement and to ascertain the types of collaborative strategies used by MMOG users and their relationship with student achievement. Findings indicated that a high level of communication takes place within game worlds (mainly social interactions) but that learners also collaborate. Leadership communication that includes providing direction by planning, organizing, distributing tasks, and evaluating performance was correlated positively to student achievement on one of the measures. Teachers, therefore, may be able to assess in-game and real-life leadership skills as students engage in game play.

A recent national survey (319,223 students, 25,544 teachers, 19,726 parents, and 3,263 school leaders) reports that educators are missing the opportunity to use games and simulations to teach core academic content (Stansbury, 2008). The survey indicates that students' top must-have emerging technology is gaming. More than 50% of students in grades 3 to 12 would like more gaming in the curriculum, but only 19% of parents and 15% of administrators favor their integration. Only 1 in 10 teachers utilize gaming in their instructional program.

Students' cited desire for educational gaming is based on the competition element in games, the ability of games to assist in understanding difficult concepts, the engagement aspect, and the fact that they would learn more about the subjects being taught.

Whether educators are ready to embrace completely games, specifically MMOGS into the classroom depends upon whether scholars can make a case for the inherent learning benefits that students and other researchers proclaim they have.

Afterward

On a personal note, since I began teaching in the late 1980s, I have always been an enthusiastic proponent of the use of technology as a tool to support learning. During this study, I have become an even more fervent advocate of the judicious use of classroom technology. I realize that video games are not a panacea or the centerpiece of learning, but they are powerful instruments.

Each day of the treatment period I witnessed true enthusiasm for the learning activities afforded in *Web Earth Online*. Educators recognize that student motivation and excitement can be leveraged in myriad ways and can be an avenue to other rich learning experiences. Three months after the treatment period, students are still playing the game and learning about other animals that share the bluebird habitat.

I was especially overwhelmed by the real-world community of practice that organically formed as bluebird experts eagerly shared their knowledge with me about the Eastern Bluebird so that I could develop a concept map that reflected key information about the bluebird life cycle and survival needs from bluebird authorities.

This community of practice based on a virtual game has extended to my real world and impacted me deeply. Not only have I become a member of the North American Bluebird Society, but also I believe that I will always be drawn to this marvelous bird and the joy it brings. And yes, I believe that I will always recognize its melodious song.

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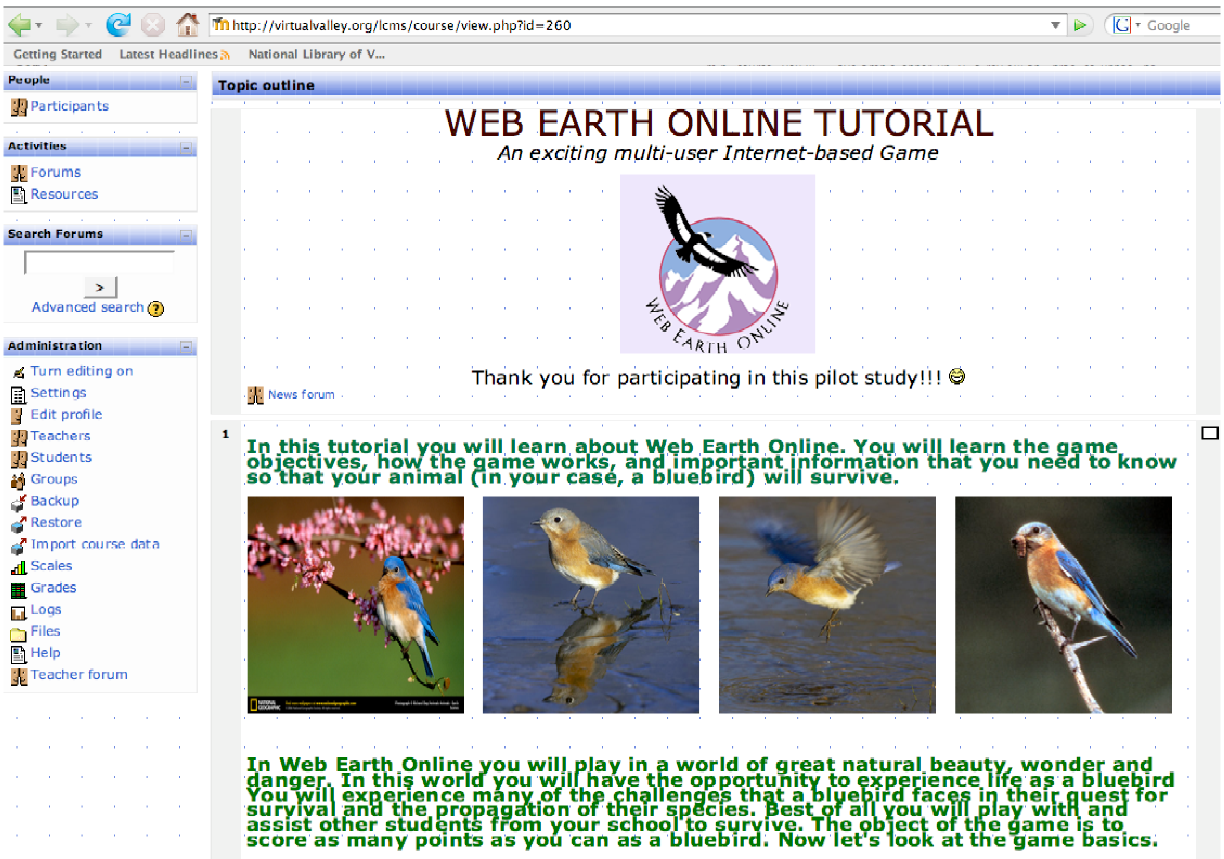
Appendixes

Appendix A Web Earth Online Tutorial Screenshot


http://virtualvalley.org/lcms/course/view.php?id=260
Getting Started
Latest Headlines
National Library of V...
People
Participants
Activities
Forums
Resources
Search Forums
Advanced search
Administration
Turn editing on
Settings
Edit profile
Teachers
Students
Groups
Backup
Restore
Import course data
Scales
Grades
Logs
Files
Help
Teacher forum
Topic outline
WEB EARTH ONLINE TUTORIAL
An exciting multi-user Internet-based Game
WEB EARTH ONLINE
Thank you for participating in this pilot study!!!
News forum
In this tutorial you will learn about Web Earth Online. You will learn the game objectives, how the game works, and important information that you need to know so that your animal (in your case, a bluebird) will survive.
In Web Earth Online you will play in a world of great natural beauty, wonder and danger. In this world you will have the opportunity to experience life as a bluebird You will experience many of the challenges that a bluebird faces in their quest for survival and the propagation of their species. Best of all you will play with and assist other students from your school to survive. The object of the game is to score as many points as you can as a bluebird. Now let's look at the game basics.

Appendix B Endorsement Letter Junior High Principal

December 13, 2007

Dear _______________,

I am planning to conduct research to study a web-based, 3-dimensional virtual environment that immerses players through role play into a realistic ecosystem of animals of various species. My research focus is an examination of the instructional use of web-based virtual environments to support student learning.

The object of the play within the virtual world is for players to understand and respond to the needs of their animal and make the necessary decisions to optimize the survival and the propagation of the species that they represent. The activities in this game address the goals of several **California Life Science Academic Content Standards.**

I am interested in using sixth-grade students to test this online learning environment..

Your signature below indicates that you give me permission to conduct my research on campus.

____

Signature   Date

Appendix C Letter of Endorsement Sixth-grade Teacher

December 13, 2007

Dear ____________,

I am planning to conduct research to study a web-based, 3-dimensional virtual environment that immerses players through role play into a realistic ecosystem of animals of various species. My research focus is an examination of the instructional use of web-based virtual environments to support student learning.

The object of the play within the virtual world is for players to understand and respond to the needs of their animal and make the necessary decisions to optimize the survival and the propagation of the species that they represent. The activities in this game address the goals of several **California Life Science Academic Content Standards.**

I am interested in using your sixth-grade science students to test this online learning environment.

Your signature below indicates that you give me permission to conduct my research with your students.

____

Signature   Date

Appendix D Passive Consent Letter to Sixth-Grade Parents

December 13, 2007

Dear Sixth-grade Parent:

My name is _______. I am the Director of Curriculum and Instruction at ___________ and a doctoral student in the ________________________________

My dissertation research examines the instructional use of web-based virtual environments to support student learning. I am currently planning to conduct research with sixth-grade students comparing traditional life-science instructional delivery to web-based instructional delivery. The learning objectives embedded in the life-science instructional unit focuses on animal life cycles and survival needs, a regular part of the sixth-grade science curriculum at ______________________.

The Superintendent of ___________, ________________, the Junior High principal, ________________, and sixth-grade science teacher, ____________, have endorsed my research study that focuses on data derived from student's regular course of instruction.

I am requesting your permission to use the anonymous student demographic (gender, age), pre-and posttest (concept map and the instructional unit scores) and student interaction data (problem-solving dialog) collected during the instructional unit for analysis in my research.

To ensure anonymity, ____________ will assign an identification (ID) number to each student. The list of ID numbers will be kept in a separate location from the data that I will analyze and the list will be disposed of at the conclusion of the study.

Please sign and return this document to ________ by **Thursday, December 20, 2007** if you **DO NOT** give permission for your student's anonymous demographic and pre- and posttest to be used in the research study. Thank you.

Please feel free to contact me at _________ or by email at ______________________ if you have questions.

Sincerely,

____

Director of Curriculum and Instruction

____

________No, I **DO NOT** give permission for my student's anonymous demographic, pre- and posttest, student-interaction data to be used in the research study.

____

Parent's Signature

____

Student's Name

Appendix E Game Experience Survey

GAME EXPERIENCE SURVEY QUESTIONS

Directions: Use the accompanying Scantron Sheet to bubble in your responses to each of the questions below. **A** indicates strongly disagree (SD) and **E** indicates strongly agree (SA).

	SD A	B	C	D	SA E
1. I play video games regularly.	1	2	3	4	5
2. I am an expert video game player.	1	2	3	4	5
3. I have played video games before.	1	2	3	4	5
4. I have played an online game where I am a character in a virtual environment.	1	2	3	4	5
5. I have used online chat features during game play.	1	2	3	4	5
6. I usually have difficulties moving up to the next game level.	1	2	3	4	5
7. I have never played a video game.	1	2	3	4	5
8. I am not good at playing video games.	1	2	3	4	5
9. I am not familiar with online chat features in video games.	1	2	3	4	5
10. I chat with other players during video game play to get help.	1	2	3	4	5
11. I am comfortable using computer technology.	1	2	3	4	5
12. It is easy for me to move up to the next video game level.	1	2	3	4	5
13. I am good at playing video games.	1	2	3	4	5
14. I seldom play video games.	1	2	3	4	5
15. Gender A= Male; B= Female	1	2	3	4	5
16. Age A= 10; B= 11; C=12; D=13	1	2	3	4	5

Thank you for completing this survey.

Appendix F Academic Content Test

BLUEBIRD SURVIVAL SKILLS – PRETEST/POSTTEST

Use the accompanying Scantron Sheet to bubble in the best answer for the matching and true and false items below.

ID # ____

1) Which season is not the mating season of the bluebird?
   a) fall
   b) winter
   c) spring
   d) summer

2) Which of the following is not typically used by the Eastern Bluebird to build a nest?
   a) grasses
   b) twigs
   c) pine needles
   d) dirt

3) Nearly 70% of the Eastern Bluebird's diet consists of
   a) nuts
   b) snails
   c) insects
   d) earthworms

4) Which is not an element of bluebird courtship?
   a) song
   b) wing-wave
   c) flight-display
   d) fluttering

5) Which of the following is not true about nest building?
   a) cold weather may temporarily stop nest building
   b) the female bluebird selects the nest building site
   c) the female bluebird typically builds the nest
   d) nest building typically takes longer than two weeks

6) During the breeding period
   a) males bring food to the female bluebird during incubation
   b) 5 eggs per day are laid
   c) eggs are bright yellow
   d) eggs are laid in the afternoon

7) Which is not true of the nestling phase?
   a) young are born with no feathers
   b) eyes are open on the 4th to 7th day
   c) bluebirds are completely feathered after 30 days
   d) nestlings that do not survive are removed from the nest by the adult bluebirds

8) Eastern Bluebirds are
   a) hole diggers
   b) mountain dwellers
   c) cavity nesters
   d) water dwellers

9) To avoid harm it is important for Eastern bluebirds to remove __________ and ___________ from nests.
   a) nestlings and fledglings
   b) twigs and pine needles
   c) insects and seeds
   d) parasites and waste

10) Which is not a preferred habitat of the Eastern Bluebird?
   a) dense forests
   b) pastures and orchards
   c) natural grasslands
   d) open forests

11) Eastern Bluebirds care for their feathers to maintain ?
   a) flight
   b) body temperature
   c) blue color
   d) attraction to mate

12) The Eastern Bluebird has difficulty when parasites invade the _____________.
   a) insects
   b) nesting material
   c) drinking water
   d) predators

13) Recently hatched nestlings
   a) can typically find food on their own
   b) rely on their adult parents for everything
   c) are able to fly short distances
   d) move on the ground in search of prey

14) Which organ uses gravel or pebbles to aid in the digestion of food?
   a) beak
   b) gizzard
   c) esophagus
   d) stomach

15) Bluebirds are more safe from predators when
a) they are in trees or in the air
b) they are hidden within bushes and shrubs
c) they are in their nests
d) they travel as a flock

16) Which of the following is not a way that bluebirds forage for food?
a) waiting for dropped food from larger animals
b) capturing insects from foliage or the ground
c) spotting food from a perch
d) catching insects that they see in midair

17) Which of the following is not done by bluebirds to avoid overheating
a) decrease activity during the heat of the day
b) nest building
c) bathing
d) resting in shady resting areas

18. Which of the following is not a bluebird socialization behavior?
a) bathing
b) vocalization
c) wing-flapping
d) courtship behavior

19. Food and nesting material is more difficult to find in the
a) summer
b) winter
c) fall
d) spring

20) It is difficult for Eastern Bluebirds to catch insects in midair?
a) true
b) false

21) Male bluebirds help to incubate eggs.
a) true
b) false

22) Female Eastern Bluebirds are a duller gray-blue color.
a) true
b) false

23) The gizzard is an organ that assists in reproduction.
a) true
b) false

24) The young of the Eastern Bluebird leave the nest within three days of hatching.
a) true
b) false

25) Eastern Bluebirds build cavities within trees for nesting.
a) true
b) false

26) Newly hatched Eastern Bluebirds are called nestlings.
a) true
b) false

27) Female Eastern Bluebirds typically lay 1-3 eggs at a time.
a) true
b) false

28) The female Eastern Bluebird is responsible for caring for the young.
a) true
b) false

29) The wing-wave communication gesture is used by male and female Eastern Bluebirds.
a) true
b) false

30) The main source of the Eastern Bluebird's energy is their flying ability.
a) true
b) false

31) Bluebirds may reuse a nest to raise a second brood.
a) true
b) false

32. Bluebird nestlings need little care and attention after the eggs have hatched.
a) true
b) false

33. Bluebird self-maintenance such as feather preening, feeding, and bathing take up the majority of the bluebird's time and energy.
a) true
b) false

34. What is your gender?
a) Male
b) Female

35. What is your age?
a) 10
b) 11
c) 12
d) 13

Appendix G Collaborative Message Examples

Look out for the dangerous animals

We only have _ minutes left

Make sure that your bird isn’t dirty

We should think about nesting

You guys should eat lots of gravel

Use the fly button instead of the arrows

Thanks for the idea

Appendix H Game Satisfaction Survey

GAME SATISFACTION SURVEY QUESTIONS

Directions: Circle your responses to each of the questions below. **1** indicates strongly disagree (SD) and **5** indicates strongly agree (SA).

	SD A	B	C	D	SA E
1. I liked playing the WebEarth Online game.	1	2	3	4	5
2. I learned a lot about the survival of the bluebird by playing Web Earth Online.	1	2	3	4	5
3. The chat feature that I used to communicate kept me from playing the game well.	1	2	3	4	5
4. I understood the function of the game tools.	1	2	3	4	5
5. I have the same amount of knowledge about bluebird survival as when I started playing Web Earth Online.	1	2	3	4	5
6. I used the help menu if I got stuck.	1	2	3	4	5
7. The game was confusing.	1	2	3	4	5
8. I did not learn much about the survival of the bluebird in the virtual environment.	1	2	3	4	5
9. I used the game help tools when I got stuck.	1	2	3	4	5
10. It was easy for me to keep earning points.	1	2	3	4	5
11. My ability to talk with other players during the game made playing more enjoyable.	1	2	3	4	5
12. I would recommend this online game to my friends	1	2	3	4	5
13. I played WebEarth Online on days other than the study period.	1	2	3	4	5
14. The Web Earth Online game was not enjoyable to me.	1	2	3	4	5
15. I was able to play the game better by communicating with other players using the "Say" button.	1	2	3	4	5
16. Talking with other players during game play took the fun out of the game.	1	2	3	4	5
17. I played WebEarth Online at other times outside of the study period.	1	2	3	4	5
18. If yes above, how many hours did you play per week 1= 1-5 2= 6-10 3= 11-15 4=16-20 5= More than 20	1	2	3	4	5
19. Gender A= Male; B= Female	1	2	3	4	5
20. Age A= 10; B=11; C=12; D=13	1	2	3	4	5

Thank you for completing this survey.

Appendix I Instructional Unit Satisfaction Survey

INSTRUCTIONAL UNIT SATISFACTION SURVEY QUESTIONS

Directions: Circle your responses to each of the questions below. **1** indicates strongly disagree (SD) and **5** indicates strongly agree (SA).

	SD A	B	C	D	SA E
1. The learning activities in the unit were interesting.	1	2	3	4	5
2. The unit helped me learn about the bluebird.	1	2	3	4	5
3. Working with my classmates helped me learn.	1	2	3	4	5
4. I understood the learning focuses of the unit.	1	2	3	4	5
5. The technology tools that were used in this unit engaged me in the learning.	1	2	3	4	5
6. The materials that we used in the unit were useful for learning.	1	2	3	4	5
7. This unit has caused me to become more interested in this topic.	1	2	3	4	5
8. I would have learned more by working alone rather than with other students.	1	2	3	4	5
9. The technology tools in the unit did not excite me about the learning.	1	2	3	4	5
10. I don't have a desire to learn more about the topic of this unit.	1	2	3	4	5
11. I wasn't sure of the learning goals for this unit.	1	2	3	4	5
12. The materials that we used in the unit were not effective for learning.	1	2	3	4	5
13. The instructions in the unit were confusing.	1	2	3	4	5
14. The learning activities in the unit were boring.	1	2	3	4	5
15. The instructions in this unit were easy to follow.	1	2	3	4	5
16. Overall, I would rate the content of this unit as very good.	1	2	3	4	5
17. I didn't learn about bluebirds in the unit.	1	2	3	4	5
18. Gender A= Male; B= Female	1	2	3	4	5
19. Age A= 10; B=11; C=12; D=13	1	2	3	4	5

Thank you for completing this survey.

Appendix J Comparison Group Instructional Unit

Academic Standards

Science Content Standards for California Public Schools, 2000, Pg 20
Strand - Ecology (Life Sciences)

Organisms in ecosystems exchange energy and nutrients among themselves and with the environment. As a basis for understanding this concept:

6. Students know matter is transferred over time from one organism to others in the food web and between organisms and the physical environment.
7. Students know populations of organisms can be categorized by the functions they serve in an ecosystem.
8. Students know different kinds of organisms may play similar ecological roles in similar biomes.
9. Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.

Instructional Parameters

Grade Level: Sixth
Each class period will be a self-contained 50-minute class session. Students will work collaboratively, use role play, conduct research, design curricular-based products and interact with multimedia tools.

Room Preparation
Decorate the classroom walls with artifacts that reflect animal habitats including habitats that are ideal for the Eastern Bluebird and habitats that are not. Choose one wall that provides a "closeup" of the bluebird habitat (a tree cavity). Provide resources that students can use to learn more about the Eastern Bluebird such as reference books, children's books, poems, photos, nest boxes, sound files, and music. The reference materials should include information on the survival needs of the Eastern Bluebird. List the content standards that will be addressed during the course of the unit on poster paper and place the standards in a prominent location in the classroom. Refer to the standards often during instruction.

Day 1

Overview
The bluebird is like a speck of clear blue sky seen near the end of a storm… (Henry David Thoreau, 1859)

Bluebirds are one of North America's most beautiful songbirds. For decades, they have been the inspiration of creative lyricists, gifted poets, masterpiece artists, and writers. Since the early 1970s there has been a growing movement in the United States to protect the declining bluebird population through the establishment of bluebird trails and the design of manmade nest boxes to care for this delicate bird and optimize the propagation of the species. There are three types of Bluebirds: Eastern, Western, and Mountain This unit of instruction focuses on the Eastern Bluebird life cycle and survival needs within its natural habitat.

Activity

Show National Geographic Clip - *From the Edge of Extinction*
http://video.nationalgeographic.com/video/player/animals/birds-animals/perching-birds/bird_blue_nesting.html

Brief overview of the cause of the decline and resurgence of the bluebird population

Discuss the plight of the Eastern Bluebird and its near extinction. Play the bluebird song (Bluebird by J.J. Cale) Show images of bluebirds as song plays. After the song is complete show new images of bluebirds, pointing out the differences in coloring between the male and female bluebird. Replay the bluebird song with images. Based on what students learned about the gender of the bluebirds, ask students to use hand signals to indicate the gender and age of the bluebirds.

Material Needed: LCD projector, computer, screen

Unit Brainstorm

Activity

Thinking Together: *Break students into cooperative groups. Ask students within groups to brainstorm and record the questions that should be addressed in a unit on the life cycle and survival needs of a bluebird. After a period of brainstorming, create a master list of questions. Highlight from the list of questions the ones that will be addressed. Ask students to share within their groups what they already know about the questions that will be addressed. Create a master list of what students "already know". As questions are answered during the course of the unit, they will be checked off on the master list.*

Material Needed: construction paper, butcher paper (or giant post it notes), markers

Day 2

Bluebird Appearance and Habits

Learning Objectives

- Compare the appearance of the male and female bluebird
- Describe the appearance of bluebird nestlings and recently fledged bluebirds
- Explain the varied ways that the bluebird uses flight
- Distinguish between male and female courtship behaviors
- Analyze bird communication
- Identify bluebird self-maintenance processes
- Practice notetaking

Vocabulary: fledgling, nestling, plumage, thermoregulation, preen, hawking, drop-feed, wing-wave, parasites

Ask students to take notes on the powerpoint handouts during the presentation about bluebird appearance, flight, and communication, and self maintenance. Pass around a hand full of paper clips to demonstrate the weight of bluebirds (30 paper clips).

Appearance
Eastern bluebirds are small birds with short, slender beaks and short legs. They are brightly colored, with a blue upper body, red breast, and white abdomen. They have large eyes, round heads, and slender, short bills which are wide at the base. Males have wing and tail feathers that are blue with black or gray shafts and tips. Their heads are a lighter shade of blue, which fades into a red throat and breast area. The breast and belly are white with light blue tips on some of the longer feathers. Females also exhibit this pattern of coloration, although they tend to be duller than males and have more gray. Adult weight ranges from 27 to 34 grams. They are, on average 18 cm long from the tip of their beak to the end of their tail. Young bluebirds are grayish in color. They have speckled breasts and their wings are tipped in blue. The blue color becomes much more prominent and the speckles on their breast disappear as they become adults.

Activity

Show Pictures of Eastern Bluebirds – Male, Female, and Young bluebirds

Material Needed: LCD projector, computer, screen

Flight
For short flights (perch to perch), bluebirds move their wings more rapidly than for longer distances. Eastern bluebirds use flight to catch prey in midair (hawking), to hover as the hunt for food on the ground, and to "drop feed" (dropping from perch to ground and back to perch). The maneuvering that bluebirds use to land in nest boxes or nest cavities demonstrates skill and agility. Bluebirds may also fly at one another if they are fighting during breeding or if they are disputing over a mate, territory, or nest cavity. Oftentimes flights are accompanied by song. Communication is also accomplished through flight techniques.

Communication

Bluebird communication through gesture and sounds are important for breeding and survival. Rapid wing movement during a special flight is done during courtship. A wing-wave display (bluebird lifts one or both wings in a quick wave) done by both males and females during breeding while the bluebird is perched is another aspect of the courtship ritual. Male bluebirds use attention-getting wing waves at nest entrances to attract possible mates.

Bluebird song is used by males and females but primarily by males to announce his presence, attract a female, and to communicate with his mate, The song of the male bluebird differs based on the song's purpose: to attract a mate, showing aggression against other males, or during disturbances of the nest. Calls are short syllables of the song and are used often among bluebird pairs and families. Shorter calls may signify alarm or aggression.

Activity

Play audio clips of Eastern Bluebirds – *Male, Female, and Young bluebirds*
Allow students to mimic calls

Material Needed: computer, speakers

Self-Maintenance

Birds' feathers protect the skin and are important for thermoregulation. Bluebirds apply secretions (waxes, fatty acids, fat, and water) and bathe often to clean feathers and remove dirt, dust, parasites, bacteria, and fungi.

Day 3

Break students into cooperative groups of experts who will use their notes from the previous day as well as additional reference material to extend what they have learned about one of the areas (bluebird appearance, communication, flight, and self-maintenance). Instruct each group to produce a report that they will present to the rest of the class.

Day 4

Activity

Bird Behavior: *Give each student several index cards. Show hard copy images of bluebirds to students. Ask students to consider what they have learned thus far about the bluebird and write what they believe the bluebird behavior is that they see in the image (an image of a male bluebird with wings spread may indicate courting behavior). Encourage students to create reasonable responses. Randomly call on students to share their responses.*

Bluebird Diet

Learning Objectives
Describe the primary diet of the Eastern Bluebird
Compare the diet of bluebirds in cool and warmer temperatures
Describe how bluebirds capture prey
Describe how energy relates to food intake
Define the purpose of the gizzard in food digestion

Vocabulary: Forage, prey, gizzard

Eastern bluebirds eat a variety of foods depending on the season. In summer months, eastern bluebirds consume mostly beetles, crickets, katydids, caterpillars, grasshoppers, sow bugs, millipedes, centipedes, snails and other insects. A United States Biological Survey study of 855 eastern bluebirds found that the bluebird diet was 68% insects. In cooler weather, the bluebird requires more energy to maintain body temperature. During the fall and winter seasons, when insects are less common, eastern bluebirds rely on other food from trees, shrubs, vines, and seeds and berries such as what is listed below.

Trees

- American Mountain Ash (Sorbus americana)
- Shadbush (Amelanchier canadensis)
- Flowering Dogwood (Cornus florida)
- Alternate-leaf Dogwood (Cornus alternifolia)
- American Holly (Ilex opaca)

Shrubs

- Highbush Cranberry (Viburnum trilobum)
- Gray Dogwood (Cornus racemosa)
- Silky Dogwood (Cornus amomum)
- Red-osier (red-stemmed) Dogwood (Cornus stolonifera)
- Smooth Sumac (Rhus glabra)
- Staghorn Sumac (Rhus typhina)

Vines

- Virginia Creeper (Parthenocissus quinquefolia)
- Grape (Vitus spp.)

Seeds and Berries

- Sumac Seeds
- Hackberry Seeds
- Blackberies
- Bayberries
- Pokeberies
- Honysuckle
- Red Cedar

Day 5

The digestive system of the bluebird has 7 major parts. The food goes through the beak, then down the esophagus where it is stored in the crop. From there the bird can regurgitate it to its young or let it continue through digestion, entering the stomach. The stomach adds digestive juices to the food, and then food is transferred to the gizzard, made of extremely strong muscles, for grinding, using pebbles the bird has swallowed. Now the food enters the intestine, where the nutrients from the food enter the bloodstream to be used by the bluebird's cells. The leftovers from the intestine are released from the vent.

Activity

Time to Eat!! – Students will have an opportunity to practice how bluebirds catch flying insects in midair using simulated beaks. In cooperative groups students will catch insects (popcorn, marshmallows) using their insect-catching beaks (tweezers, chop sticks, envelope, fishnet). Students will discuss afterwards which "beak" worked better.

What's For Dinner Food Collage – Choose one of the favorite foods of the Eastern Bluebird. Find a picture of it and provide at least five facts about it to share with other students. We will create a bluebird food collage including each of the foods.

Material Needed: popcorn, marshmallows, chopsticks, tweezers, envelopes, fishnets, plant and insect books and magazines

Day 6

Bluebird Habitat and Nest Building

Learning Objectives

- Enumerate the components of a habitat
- Interpret the significance in the effect of changes in a habitat
- Build a suitable bluebird bird nest
- Summarize how animals depend on their habitat

Vocabulary: Cavity Nester,

Habitats

People and other animals share some basic needs. Every animal needs a place in which to live. The environment in which an animal lives is called "habitat." An animal's habitat includes food, water, shelter and space in an arrangement appropriate to the animal's needs.

If any of these components of habitat is missing or is affected significantly so that the arrangement for the individual animal or population of animals is no longer suitable, there will be an impact. The impact will not necessarily be catastrophic, but can be. There are a great many additional limiting factors beyond those of suitable food, water, shelter and space. For example, disease, predation, pollution, accidents and climatic conditions are among other factors which can have impact.

All things are interrelated. When we look at a biological community, we find interrelationships and interdependencies between plants and plants, plants and animals, as well as animals and animals. These interrelationships and interdependencies are important.

Activity

The need for a habitat

1. Ask the students to number off from "one" to "four." All the "ones" go to one corner of the room, the "twos" to another, etc.
2. As the students move to their corners, clear a space in the center of the room. Better still, go outside to a clear, grassy area. The "ones" should sit or stand together, "twos" together, etc.
3. Assign each group a concept as follows: " ones " =food, " twos" =water, " threes " =shelter, " fours " =space.
4. Now, it's time to form a circle! This is done by building the circle in chains of food, water, shelter and space. A student from each of the four groups walks toward the cleared area. The four students stand next to each other, facing in toward what will be the center of the circle. Four more students - one from each group - join the circle. Keep adding to the circle in sets of four until all the students are in the circle.
5. All students should now be standing shoulder to shoulder, facing the center of the circle.
6. Ask the students to turn toward their right, at the same time taking one step toward the center of the circle. They should be standing close together, with each student looking at the back of the head of the student in front of him or her.
7. Ask everyone to listen carefully. Students should place their hands on the shoulders of the person in front of them. Students slowly sit down as you count to three. At the point of three, you want the students to sit down - on the knees of the person behind them, keeping their own knees together to support the person in front of them. You then say, "Food, water, shelter and space - in the proper arrangement (represented by the students' intact, "lap-sit" circle) - are what is needed to have a suitable (good) habitat."
8. The students at this point may either fall or sit down. When their laughter has subsided, talk with them about the necessary components of suitable habitat for people and wildlife.
9. After the students understand the major point - that food, water, shelter and space are necessary for any animal's survival, and in their appropriate arrangement comprise a suitable habitat - let the students try the circle activity again! This time ask them to hold their lap sit posture. As the students lap-sit - still representing food, water, shelter and space in their appropriate arrangement - identify a student who represents "water." Then say, "It is a drought year. The water supply is reduced by the drought conditions." At this point, have the student who was identified as representing "water" remove himself or herself from the lap-sit circle - and watch the circle collapse, or at least suffer some disruption in arrangement. You could try this in several ways - removing one or more students from the circle. Conditions could vary: pollution of water supply, urban sprawl limiting availability of all components, soil erosion impacting food and water supplies, etc. Since animals' habitat needs depend upon food, water, shelter and space, in their appropriate arrangement, "removal" of any will have an impact.
10. Ask the students to talk about what this activity means to them. Ask the students to summarize the main ideas they have learned. They could include: a) food, water, shelter and space, in their appropriate arrangement, can be called habitat; b) humans and other animals depend upon habitat; c) loss of any of these elements of habitat will have impact on the animals living there; and d) the components of habitat must be in an arrangement

suitable to the needs of the individual animals or populations of animals in order for the animals to survive.

VARIATION
Have the students form a circle, holding hands. Walk around the circle, first naming one student as an animal of a particular ecosystem. Name the next four students in the circle as food, water, shelter and space for that animal. Repeat the process until all the students are involved. Any "extras" can be identified as elements of habitat, e.g., resulting from a particularly good year for habitat needs for the last animal named. When all of the students have been designated as an animal or as components of an animal's habitat, comment on the fact that they are holding hands. This represents the idea that all things in an ecosystem are interrelated. Briefly discuss the idea of interrelationships. Then move the students into position to the "lap sit" described in the procedure above.

Bluebird Habitat

Bluebirds are mostly found in open forests, at the forest edge, and in natural grasslands. Other habitats are pastures, orchards, and parks with scattered trees and low or sparse ground cover.

Bluebird Nests

The nest of the Eastern Bluebird is made of dried grasses, pine needles, weed stems, fine twigs, hairs, feathers, and lined with finer grasses. They nest mostly in North America through early March to late August. Bluebirds have 4-6 eggs that are pale blue. The eggs are laid mostly through May to July. After nesting the bluebirds gather in flocks.

Eastern bluebirds largely depend upon others for their nesting needs because the beaks of these birds are not strong enough to enable them to hollow out their own nests. Naturally occurring cavities, cavities made by other birds, and nest boxes are commonly used by bluebirds. Construction of the nest is done primarily by the female and will stay around the nest to help raise another brood. At the nest cavity, the male Eastern bluebird does a nest demonstration to attract the attention of the female bluebird, and he provides nest material.

Activity

Habit Scenario – *Place students in groups of four. Ask each student within each group to number themselves from 1-4. Advise students that you will pull from the "bird nest" (something that resembles a bird nest for effect) unique situations related to bluebird habits (e.g. you are a male bluebird and another bluebird is near your nest) You will also pull a number (1, 2, 3, or 4). Students whose number is pulled will share how a bluebird might respond to the situation based upon what they have learned about the Eastern Bluebird. Students may confer with group members but the student in each group whose number was pulled will present.*

Material Needed: Bird nest prop, slips of paper with bluebird *situations* written on them

Activity

Click on this interactive website to understand the habitat changes that affect animals like the Eastern Bluebird

http:///www.ext.vt.edu/resources/4h/virtualforest/
Old field succession

Material Needed: LCD projector, computer, screen

Activity

Build A Nest – Build a Nest: Using three different kinds of materials from outdoors (pine needles, grasses, straw, twigs, and feathers) Ask each student to make a bird nest. First, students should determine the type of bird they represent and the size of their eggs in relation to the size of the nest. In class have each student build a nest using their materials. To build appreciation for the skill and craftsmanship involved with nest construction, challenge students to use only two fingers, simulating the beak of a bird. Glue may be used to bond materials.

Discussion Questions for cooperative groups
Based on what you know about the bluebird, what is the advantage of building a nest? Disadvantages? Where would you place a bluebird nest?

Material Needed: pine needles, grasses, twigs, straw, feathers, glue

Day 7

Bluebird Predators and Dangers

Learning Objectives

List and describe key predators of Eastern Bluebirds
Identify dangers that the Eastern Bluebird faces
Recommend ways to enhance Eastern Bluebird survival rates

Common Predators

Predators of Eastern bluebirds vary greatly. Eastern chipmunks and flying squirrels prey upon eggs and newly hatched bluebirds. Adult bluebirds are preyed upon by a number of predators, including house sparrows, European starlings, fire ants, cats, black bears, small falcons, snakes, black racers, and raccoons.

Parasites

Bluebirds are sometimes infected by the parasitic blowfly (Protocalliphora sialia), which prefers cavity-nesting birds. The cycle of this parasite begins when the adult female blowfly lays eggs in the nesting material. When the eggs hatch, the larvae attach themselves to the nestlings at night and suck their blood. When gorged sufficiently, the larvae burrow back into the nesting material, surrounding themselves with a flexible membrane to resemble a small brown egg. This is the pupal stage. In 10 to 14 days, adult blowflies emerge from the pupal case, or puparia, and fly away to repeat the cycle.

Ordinarily, no action against this parasite needs to be taken. If other stress factors, such as prolonged rain, drought, or food shortages occur, blowfly parasitism can seriously weaken nestlings and control measures may be necessary to save the brood.

Activity

Staying Alive – In this cooperative activity students understand the survival difficulty that bluebirds have. Give each group a bag that contains slips of colored paper. Blue slips (five of them represent the Eastern Bluebird). Other slips of paper represent predators and other dangers (cold weather) for bluebirds. Each group member will have three turns to pull out a slip of paper (representing a season in the life of a bluebird). At the end of the three rounds count to see how many bluebirds survived.

Discussion Questions for cooperative groups

What are ways that you can think of to enhance bluebird survival rates?

Material Needed: blue slips of paper, other colors of paper representing dangers to bluebird survival, paper bag

Day 8

Courtship and Mating

Learning Objectives

Describe the courtship ritual

Sequence the life cycle of the bluebird

Compare and contrast the male and female roles in raising the young

Vocabulary: altricial, incubate, clutch, brood

Courtship

The courtship of the bluebird is as beautiful as the bird itself, and normally as gentle, unless interrupted by some jealous rival who would steal his bride; then gentleness gives place to active combat. The male usually arrives a few days ahead of the female, selects what he considers to be a suitable summer home, and carols his sweetest, most seductive notes day after day until she appears in answer to his call. Then he flutters before her, displaying the charms of his widespread tail and half-opened wings, warbling in delicious, soft undertones, to win her favor. At first she seems indifferent to the gorgeous blue of his overcoat or the warm reddish brown of his ardent breast. He perches beside her, caresses her in the tenderest and most loving fashion, and sings to her in most endearing terms. Perhaps he may bring to her some delicious morsel and place it gently in her mouth, as an offering. Probably he has already chosen the cavity or box that he thinks will suit her; he leads her to it, looks in, and tries to persuade her to accept it, but much persistent wooing is needed before the nuptial pact is sealed. In the meantime a rival male may appear upon the scene and a rough and tumble fight ensue, the males clinching in the air and falling to the ground together, a confusing mass of blue and brown feathers struggling in the grass; but no very serious harm seems to have been done, as they separate and use their most persuasive charms to attract the object of their rivalry. At times, a second female may join in the contest and start a lively fight with her rival for the mate she wants.

Mating and Breeding

Bluebirds search for natural cavities or nest boxes along the edges of woods or pastures, and in orchards, meadows, and large gardens. Hollow limbs, holes in trunks, or deserted woodpecker "apartments" are used as nest sites. These cavities range from three to 30 or more feet above ground. Competition with starlings for these natural cavities often forces bluebirds to seek nest boxes. The nest, built by the female, takes approximately 10 days to complete. These nests are small, cup-like structures that are lined with grass, feathers, stems, and hairs. Each female lays 3 to 7 (average 4 to 5) white or light-blue eggs. The female incubates the eggs , which hatch after 13 to 16 days. The young are altricial (helpless) at hatching. Fledglings leave the nest 15 to 20 days after hatching.

Mating occurs in the spring and summer months. Bluebirds produce two broods yearly, and sometimes three if weather conditions are favorable and food supplies are adequate.

Both parents cooperate in raising the young, which they feed a diet insects. Fledglings are grayish in color with a speckled breast. The blue color becomes much more prominent and the speckles on their breast disappear as they mature. Bluebirds may begin breeding the summer after they are hatched.

The parents are very meticulous about cleaning up the nestbox. When the eggs hatch, the female usually eats the eggshells to help with her egg production or disposes of them far away from the nestbox. While the babies are growing, the parents will carry away the waste products from the nestlings. The waste is in the form of neat little bundles called "fecal sacs".

Activity

Starting a Family
Bluebird Growing Up Game (Card Ordering) – use the card cutouts to sequence the stages of bluebird development

Incubation to Fledging – Live Cam Shots
http://www.bluebirdnut.com/Nesting%20Habits.htm#Whennest

http://www.birds.cornell.edu/birdhouse/nestboxcam/2007_cams/e_bluebird_heath2/index2_html

Caring for the Young – Live Cam Shots
http://www.birds.cornell.edu/birdhouse/nestboxcam/2007_cams/eabl_ky_cces1/

Material Needed: LCD projector, computer, screen, card game worksheet for each student

Summary Activity

Writing About It

Reflect on what you have leaned about the Eastern Bluebird. Write a two-page creative "A Day in the Life of an Eastern Bluebird (first person). Incorporate the facts,vocabulary, and your personal reflections as you write your story.

Material Needed: paper, pencils, pens

Unit Development References

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