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Changing the way we build games: a design-based research study examining the implementation of homemade powerpoint games in the classroom

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**CHANGING THE WAY WE BUILD GAMES: A DESIGN-BASED RESEARCH STUDY
EXAMINING THE IMPLEMENTATION OF HOMEMADE POWERPOINT GAMES IN
THE CLASSROOM**

by

JASON PAUL SIKO

DISSERTATION

Submitted to the Graduate School

of Wayne State University,

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Approved by:

Advisor

Date

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CHAPTER 1

INTRODUCTION TO THE STUDY

Learning by playing games has been touted as a way to increase motivation in learning (Gee, 2003), and their use is gaining popularity in schools (Prensky, 2010). However, Hays (2010) found that the empirical research is quite underwhelming with respect to claims that student learning is improved by playing games. While the use of games has not been found to be detrimental to student learning either, it is difficult to justify their use given the complexity of implementing games as an instructional strategy for no added benefit.

Research has also focused on the effects on learning when students design games rather than play them. The idea of learning through the construction of an artifact is called constructionism, a term first used by Papert (1980) in his work with mathematics instruction using the programming language *Logo*. While research has shown that the technique is effective, problems can exist with teaching both subject area content as well as programming (Barbour, Thomas, Rauscher, & Rieber, 2008). Therefore, researchers have begun to look at methods for designing games without having to teach a programming language. This dissertation examined the use of *Microsoft PowerPoint* as a programming tool for game design, as *MS PowerPoint* is ubiquitous in schools and requires little technical instruction (i.e., because of its ubiquity, students and teachers are generally familiar with using the application).

Homemade PowerPoint Games

Researchers examining the effectiveness of homemade PowerPoint games as an instructional strategy have listed three pedagogical justifications for their use. First, the games themselves are artifacts constructed by students. The philosophy that espouses the benefits of learning by building artifacts is known as constructionism, an extension of constructivism

developed by Papert (1980) and his work with the programming language *Logo*. Studies involving the construction of games using several different programming languages (e.g., *Scratch* and *Alice*) have shown positive effects on student learning (Kafai, 1998; Kafai, Peppler, & Chiu, 2007).

The second justification for the use of homemade PowerPoint games is the practice of writing a short, concise narrative that acts as the storyline for the game. This type of assignment is referred to as a microtheme, where students are given a writing assignment with specific constraints on the length of the product (Ambron, 1987; Collins, 2000). Students are forced to eliminate excess wording and focus on the essential details of the topic. The practice of writing microthemes has been shown to increase both student interest and achievement.

The final justification for using homemade PowerPoint games is the process of creating the challenge of the game through multiple choice questions developed by the students. When students created questions, they must develop a grammatically correct question about the content, tying it to a specific content objective, determine the correct answer, and come up with plausible incorrect alternatives. Research on this strategy has shown that question writing is an effective instructional strategy (Lotherington & Ronda, 2010; Wong, 1985), particularly when the level of scaffolding is increased (Chin & Osborne, 2008).

Despite support in the literature for each of the justifications, research examining the use of homemade PowerPoint games has been unimpressive. Studies have been conducted at the middle school level in grammar (Parker, 2004), and at the high school level in both literature (Barbour, Clesson, & Adams, 2011) and social studies (Barbour, Kinsella, & Rieber, 2011). However, in all of these studies, where the games were created as a review technique for a test, differences in student performance between groups who created games and those who did not

have not shown any statistical significance. A more complete discussion of these justifications and the related literature, which forms a manuscript that has already been submitted and is currently under review, is contained in Chapter 2 of this dissertation.

Design-Based Research into Homemade PowerPoint Games

The study described in this dissertation is a design-based research project consisting of three iterations investigating the use of homemade PowerPoint games in a secondary science classroom. As previous studies involving homemade PowerPoint games had failed to show significant differences in student performance between groups who created games and those who did not, the purpose of this study was to investigate how changes in manner that the homemade PowerPoint game project was implemented could influence student performance when compared to groups who did not create games. In addition to examining the changes made to the protocol, I examined the individual justifications for the use of homemade PowerPoint games (i.e., question writing and narrative writing) to see if the justifications, in isolation, might also produce positive effects in student performance.

Design-based research is an approach that emphasizes solving complex problems in a defined setting in order to develop or advance theory (Design-Based Research Collective, 2003). The process is iterative in nature, and decisions made are rooted in the literature (Barab & Squire, 2004). It has also been referred to as socially responsible research, in that the research is conducted as a way to improve performance and learning within a particular context (Reeves, Herrington, & Oliver, 2005). In this instance, iterations of the study have been conducted in such a way that changes were made to the implementation of a homemade PowerPoint game project based on the previous results and research conducted on constructionist learning

environments, narrative writing, and question writing (i.e., the three justifications cited by proponents of homemade PowerPoint games).

The same setting was used for each of the three iterations of the study: a large, suburban, Midwestern high school with approximately 2,100 students in grades ten through twelve. The economic makeup of the school district was primarily middle class, although all ranges of the socio-economic spectrum were well represented. The ethnicity of the school was primarily (i.e., greater than 90%) Caucasian, but this number had been steadily decreasing over the last decade.

The course, entitled Environmental Chemistry, was based on the *Chemistry in the Community* curriculum developed by the American Chemical Society (2008). The course differed from a traditional chemistry course in that it devoted less time to theory and complex calculations, and emphasized the relationships between science, technology, and society (STS). The course was intended for college-bound students who were not planning on pursuing a career in the sciences, but in reality the course was often selected by marginal students who needed credits in science to fulfill graduation requirements.

Round One

The first iteration of this study was conducted during the 2008-2009 school year. The implementation of the homemade PowerPoint game review activity was conducted over four consecutive days in the computer lab preceding the test. All of the content had been covered and students used the game construction activity in lieu of a traditional review worksheet. The four-day protocol was similar to the five-day protocol used in previous studies involving homemade PowerPoint games (Rieber, n.d.). The reason for the change in the number of days was that the school involved in the study was on a trimester system; therefore, instead of 60-minute periods, a school period was 72 minutes. On the first day, students were introduced to the homemade

PowerPoint game project and were allowed to play several games. The teacher also led a short discussion on what made games interesting and entertaining (i.e., an interesting narrative, increased level of difficulty as the player progressed, etc.). The students were then allowed to work in groups of two and were given a homework assignment to create a narrative and begin to write questions. On the second and third day, the students continued to create questions and construct the game. On the final day, students needed to finish their game, and if they did, they played their own game and the games of others to check for errors. On the following day the students took a test over the material.

I examined student performance on two unit tests, comparing the performance between students who created homemade PowerPoint games to review for each test and those who completed a traditional review. The instrument for both unit tests consisted of 40 multiple-choice questions which were validated based on the difficulty index and discrimination index. The first unit test covered topics such as natural resources and mining, while the second unit test covered content on the atmosphere, air quality, and the gas laws. For both unit tests, there was no statistical difference in student performance ($p = .26$ for the first unit test and $p = .99$ for the second unit test). Furthermore, I tested to see if being exposed to the game project on multiple occasions had an effect on student performance. Again, there was no statistical difference in student performance on the second unit test between students who created games for both units, students who only created games for the second unit, and students who did not create games for either unit ($p = .89$). The findings from the first iteration were published in the *Journal of Computing in Mathematics and Science Teaching* (Siko, Barbour, & Toker, 2011).

Barbour et al. (2009) tested the assumption that students were indeed writing more higher-order questions, as one of the justifications for the use of homemade PowerPoint games in

the classroom. However, when the researchers examined the questions written by students who created games for a U.S. history course (Barbour, Kinsella et al., 2011), they found that almost all of the questions were “Knowledge” level questions (i.e., questions involving simply recall). Similar to the study conducted by Barbour et al. (2009), I also wanted to test the assumption that students wrote higher order questions when creating their homemade PowerPoint games. Using Bloom’s taxonomy (Bloom, 1956), two subject matter experts (i.e., instructors for the course where the study was conducted) rated each of the questions created by students in the study by Siko et al. (2011). For games created during the first unit, approximately 61% of the questions written were “knowledge” level questions. For games created during the second unit approximately 68% of the questions were “knowledge” level. For games created in the second unit, students who had more experience creating games (i.e., they created games for both units) wrote more higher order questions than those who had not created games before, but the difference was not found to be statistically significant (this manuscript is currently under review; see Appendix H for a copy).

Round Two

For the second iteration of the study, several changes were made to the game implementation protocol. These changes included turning the games into a unit project rather than a review, providing more instruction and feedback on question writing, and minimum requirements for question difficulty (i.e., the teacher set limits on the number of “knowledge” questions that could be included in the game). For the first unit, students who did not create homemade PowerPoint games performed statistically significantly higher on the unit test than students who did create games ($p = .023$). As a result, additional instruction on question writing and due dates for drafts of the narratives and questions were instituted for the second unit test.

For the second unit, students who created games performed statistically significantly higher on the unit test than students who did not create the games ($p = .004$). This was the first statistically significant result in favor of students creating homemade PowerPoint games, not only in this line of study but also any previously published research on the use of the games. The manuscript describing the results of the second round of the study forms Chapter Three of this dissertation.

Using the round two data, I also conducted a study examining other factors that could influence achievement in chemistry. Previous research had indicated that several factors can influence performance in chemistry classes, such as previous chemistry achievement, math achievement, achievement in previous science classes (i.e., biology is usually taken before chemistry in a traditional high school sequence), and overall grade point average (Andrews & Andrews, 1979; Barthel, 2001). Using multiple regression, I found that for the first unit test, despite research which stated that math achievement played a larger role in predicting chemistry performance (Andrews & Andrews, 1979), the best predictors of performance on the first unit test in this study was the performance on previous tests in the course (this manuscript is currently under review; see Appendix G for a copy).

Round Three

The third iteration of the study occurred during the 2011-2012 school year. The study incorporated the changes made for the second unit in the second iteration of the study (e.g., unit project instead of review, requirements on question difficulty, submission of drafts, opportunities for feedback, and the use of corrective feedback in the game). In addition, the project emphasized linking student questions more closely to the narrative, and that the narrative was more apparent throughout the whole game rather than just the beginning. The third iteration also examined the individual justifications for the use of homemade PowerPoint games by examining

differences in student performance when these justifications (i.e., narrative/microtheme writing and question writing) were isolated (i.e., used as instructional strategies without the games). The results of this study are detailed in Chapter Four.

Overview of this Dissertation

The use of games in the classroom as a tool for learning has been gaining popularity but empirical support has been minimal. The use of game design as an instructional method has been shown to be an effective strategy, and homemade PowerPoint games are an accessible way to incorporate elements of game design pedagogy without additional instruction in computer programming. Chapter Two contains the literature review manuscript that is currently under review. It begins with a discussion of the use of games in education, in particular the rationale and success for the use of game design. Next it describes the homemade PowerPoint game project, including the three justifications that proponents use as the rationale for the project. This is followed by a critique of the existing research into the use of homemade PowerPoint games in a variety of K-12 settings. Finally, it discusses potential directions for future research with homemade PowerPoint games.

In the first iteration of our study using homemade PowerPoint games to teach science, I found that creating games as a review exercise did not show a statistical improvement over traditional review methods. When adding additional structure to the implementation and by making it a unit project rather than a review exercise, I found that student performance was statistically significantly higher than students who did not construct games. Chapter Three contains the manuscript for the second iteration of the study, which is also currently under review. It begins with a brief literature review of the justifications for the use of homemade PowerPoint games and previous research examining the use of the games in the classroom. It

then details the methodology for the second iteration of the study, followed by the results. For the first unit, the students who did not create homemade PowerPoint games performed statistically higher than those who created games. For the second unit, the students who created games performed statistically higher than those who did not. The manuscript concludes by providing recommendations for the third iteration of the study, including a better alignment of the narrative and questions to create a game where players are asked to answer questions related to the practice of science.

Chapter Four contains the manuscript for the third iteration of the study. In addition to refining the implementation of the game design project based on the recommendations from previous iterations, the individual justifications for the use of homemade PowerPoint games were tested in isolation. When the instructional strategies were tested in isolation, both microtheme assignments and question writing assignments had a positive but not statistically significant effect on student test performance. Further, the changes made to the implementation of the game design project in both trimesters also increased student test scores; however, those changes were not statistically significant when compared to students who did not create games or students who created games in the previous iterations.

Chapter Five contains a summary of the lessons learned from the three iterations for practitioners wishing to use homemade PowerPoint games in their classrooms, as design-based research can work to resolve several of the issues concerning both research in instructional technology and education in general. Reeves (1995) noted how socially responsible research in instructional technology should not simply focus on how instructional works, but also how it can make education better. The chapter begins with a description of homemade PowerPoint games for practitioners, which is then followed by a brief summary of the justifications for their use and

a summary of the research examining their use in classrooms. I then detail how the implementation of the game design project has evolved over the three iterations of the study. I conclude by providing a practitioner with several principles to abide by when using a game design project as an instructional strategy. These principles are general and could be applied to a project using a platform other than *MS PowerPoint*.

The final chapter of this dissertation considers all three rounds of this design-based research study. While many of the findings were not statistically significant, changing the game design project from a review exercise to a unit project and the addition of corrective feedback to the game design resulted in statistically significant differences in student test performance. In addition, increased levels of instruction and structure to the project helped the games become less drill-and-practice in nature. Practitioners should look to add these features to a game design project, as well as encourage a better alignment between the narrative and the content. For example, games created for a science course should be designed around process and inquiry skills in addition to factual content. I conclude the chapter with several directions for future research. Researchers should examine the effects of a game design project on motivation, the effects on students' inquiry and process skills, and whether the design principles suggested over the three iterations are transferrable to games created with other programming languages.

In addition to the six chapters, several additional materials are included in the appendices. The first four appendices (i.e., A-D) contain the instruments used in the three iterations of the study. Appendix E contains the student directions and grading rubric for the third iteration of the study. Appendix F contains the narrative writing framework from which students developed their game in the third iteration. Appendix G contains a manuscript currently under review that examined additional factors that could predict the test scores for the first unit test in the second

iteration of the study. Appendix H contains a manuscript current under review that analyzed the questions written by students in the first iteration of the study.

Definition of Terms

Bloom's taxonomy – classification of the cognitive domain, which consists of six behaviors (in order of increasing complexity) knowledge, comprehension, application, analysis, synthesis, and evaluation (Bloom, 1956).

Constructionism – concept of learning by making; a belief that students learn through the construction of artifacts (Papert, 1991). The artifact is created as a result of a set of driving questions or activities, and acts as a representation of student cognition that can be shared and critiqued (Rieber, 2004).

Design-based research – An iterative research process focused on complex problem solving and theory development that is defined by five proposed characteristics:

- The design of learning environments and the development of theories of learning are intertwined;
- Development and research take place through continuous cycles of design, enactment, analysis, and redesign;
- Research on designs must lead to sharable theories that help communicate relevant implications to practitioners;
- The research must account for how designs function in authentic settings; and
- The development of such accounts relies on methods that can document and connect processes of enactment to outcomes of interest (Barab & Squire, 2004, p.5).

Homemade PowerPoint Game – any of a variety of educational games created using Microsoft PowerPoint. For the purposes of this document, all of the games were created from a template downloaded from <http://it.coe.uga.edu/wwild/pptgames/>.

Microthemes – short writing assignments that actively engage students with the content (Ambron, 1987).

Microworld - a “subset of reality or a constructed reality whose structure matches that of a given cognitive mechanism so as to provide an environment where the latter can operate effectively” (Papert, 1980, p. 204). The attributes that must exist in order to define something as a microworld include the following:

- it is domain specific;
- it provides a doorway to the domain for the user by offering a simple example of the domain that is immediately understandable by the user;
- it leads to activity that can be intrinsically motivating to the user – the user wants to participate and persist at the task for some time;
- it leads to immersive activity best characterized by words such as play, inquiry, and invention; and
- it is situated in a constructivist philosophy of learning. (Rieber, 2004, p. 588)

Narrative – a story. The simplest definition of a narrative is somebody telling someone that something happened (Norris, Guilbert, Smith, Hakimelahi, & Phillips, 2005). The narrative can contain eight elements: an event token (i.e., some starting point), a narrator, a narrative appetite (i.e., why should we listen), past time, structure, agency (i.e., the characters), the purpose, and the reader.

Question writing – the process by which students construct their own questions based on the content of the course. As an instructional strategy, question writing can direct learning and drive knowledge construction, foster discussion and debate, help to monitor understanding, and increase motivation (Chin & Osborne, 2008). In the case of this study, students must create not only the question, but a single correct answer and several plausible yet incorrect options as well (Barbour, Rieber, Thomas, & Rauscher, 2009).

CHAPTER 2

GAME DESIGN AND HOMEMADE POWERPOINT GAMES: AN EXAMINATION OF
THE JUSTIFICATIONS AND A REVIEW OF THE RESEARCH

Aldrich (2005) defined an educational game as a simulation that has elements of entertainment. While their purpose is to educate, games themselves, "...do not support learning objectives directly" (p. 85). Games have built-in inefficiencies. For example, Aldrich stated that there are numerous ways of putting a ball in a hole that are better than using a golf club, that make obtaining the objective more time consuming yet more enjoyable at the same time. At a deeper level, games provide learners with opportunities to collaborate, problem-solve, and to develop a sense of place in a simulated world through self-discovery (Kafai, 2006). Games can help contribute rich experiences that are often not found in a traditional classroom setting, and those experiences can provide skills that students need in the twenty-first century (Kebritchi & Hirumi, 2008).

Research has shown that games been found to increase motivation, teach complex understanding, provide opportunities for reflective learning, and give feedback and points for self-regulation (Betrus & Botturi, 2010). However, games are not a panacea for all that ails education (Prensky, 2008); for all of their benefits as a tool for maintaining motivation and interest (Gee, 2003), empirical research has not made a convincing case for their use in classrooms (Hays, 2010). The research has often shown neither an advantage nor disadvantage over traditional instructional methods, and given the complexity of tying instruction to games, one could question the extra use of time and other resources for little or no additional benefit.

While research has often focused on how students learn by playing games, a separate line of research has examined the effects of students acting as designers of educational games. The

idea of students learning by building an artifact, such as a game, has been called constructionism (Papert, 1991). Kafai (2006) contrasted the instructivist method of using games as a way to sweeten learning, where through game design students construct knowledge while building technological fluency through their design decisions.

One of the problems associated with game design as an instructional strategy is the time commitment involved; in addition to the content, students must learn a programming language as well (Barbour et al., 2008). The teacher may not have the requisite skill to program, let alone teach how to program in a computer language. Therefore, researchers have looked at “low-tech” ways to have students create games while still using computers, getting the benefits believed to be associated with constructionist teaching without the time and resource allocation. One way teachers can use game design to teach is by using *Microsoft PowerPoint* as a game design tool. *MS PowerPoint* is ubiquitous in schools, and while it does not have the capabilities of many programming languages such as *Scratch* or *Alice*, it requires little additional instruction before students can begin designing games.

Proponents of homemade PowerPoint games have provided three philosophical justifications to support their use as an instructional tool (Barbour, Thomas, Rauscher, & Rieber, 2010). First, the games are consistent with constructionist pedagogy. Second, the students gain a deeper understanding of the material by writing concise narratives for the games. Third, the students must write quality questions for the game, which further enhances their understanding of the material. However, despite these justifications, studies involving the use of *MS PowerPoint* as a game design tool have, for the most part, shown no benefits to student performance over traditional methods (Barbour, Clesson et al., 2011; Barbour, Kinsella et al., 2011; Parker, 2004; Siko et al., 2011). Current research is being conducted to examine why

instruction using homemade PowerPoint games have not shown additional benefits over traditional methods of instruction. The purpose of this literature review is to examine whether prior research and implementation of homemade PowerPoint game projects were congruent with the justifications for their use. In other words, was there evidence of the three justifications in each of the previous studies involving homemade PowerPoint games?

In this literature review, we will first describe homemade PowerPoint games in detail. We will then review the research on homemade PowerPoint games to date. We will then examine research on the three philosophical justifications for using homemade PowerPoint games in the classroom: 1) constructionism (as it relates to games and game design), 2) the use of narratives as an instructional tool, and 3) student generated questions. In the results section, we will discuss how the studies examining homemade PowerPoint games demonstrate the three justifications. Finally, we will identify future directions for research involving homemade PowerPoint games.

Methodology

In order to conduct the literature review, the authors researched the literature using two methods. With respect to studies on homemade PowerPoint games, the literature was collected based on the authors' personal knowledge and participation in previous studies. Additional searches using Google Scholar yielded no additional results.

For the literature review on the justifications for the use of homemade PowerPoint games, we began by reviewing the supporting literature in the aforementioned studies using homemade PowerPoint games. Further, we utilized the Education Resources Information Center, ProQuest, and Academic Onefile databases, along with Google Scholar. First, we used the "cited by"

feature on Google Scholar to find more recent articles which cited the seminal works noted in the original research for the games. Second, we conducted our own searches for literature on the three justifications. We used a variety of search terms, including constructionism, game design, narratives, microtheme, writing across the curriculum, student generated questions, and student questioning. Our search was limited by the electronic databases available at Wayne State University, the Michigan e-Library and Catalog Resource System, and open access services.

What is a Homemade PowerPoint Game?

A homemade PowerPoint game is one of several low-tech games built from the *MS Office* suite (for another example of games using *MS Office*, see the game project at <http://www.excelgames.org>). Homemade PowerPoint games can be created from scratch or by using an existing template (n.b., for the research discussed in this literature review, games were created from a template which can be found at <http://it.coe.uga.edu/wwild/pptgames>). A screenshot of a title screen created from a template is shown in Figure 2.1.



Figure 2.1. An introductory screen from a typical homemade PowerPoint game.

The game can be contained completely within the *MS PowerPoint* file or the game can require additional materials (e.g., a game board or dice). In the case of the former, digital photographs or scans can be taken of a hand-drawn game board and inserted into the file, or the materials can be created in *MS PowerPoint*. An example of an external game board can be seen in Figure 2.2.

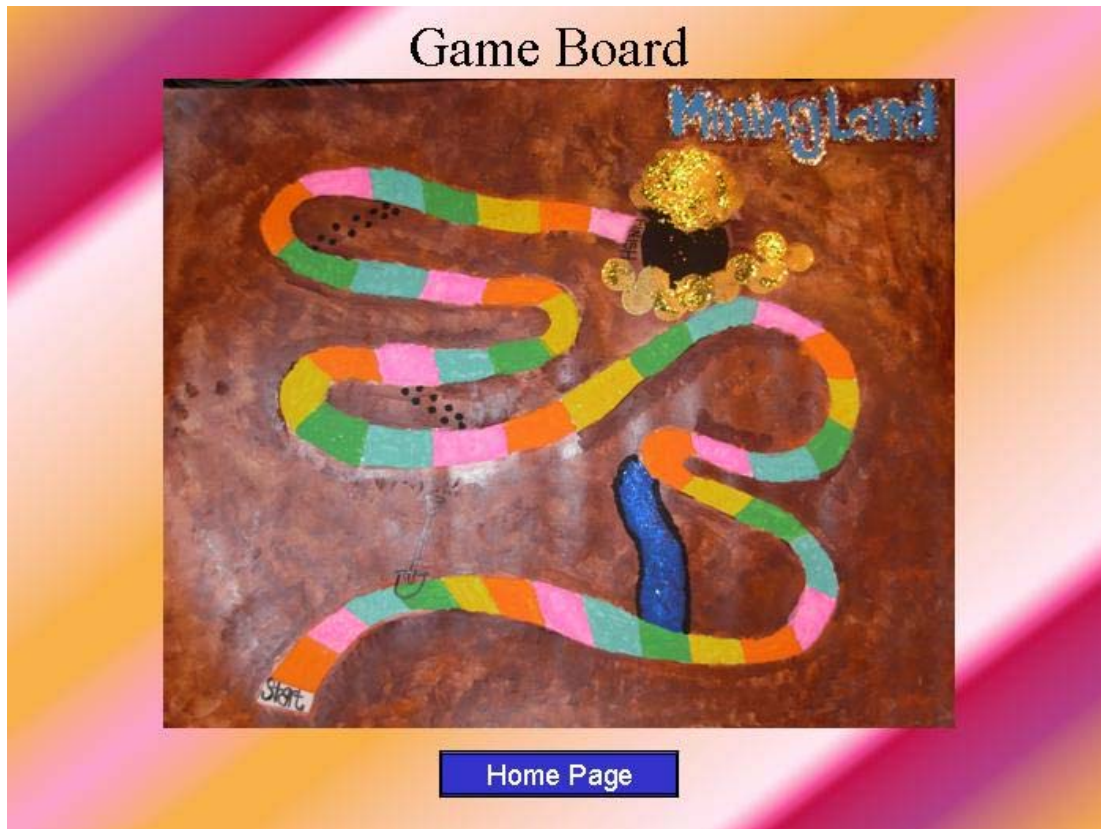


Figure 2.2. An example of a slide containing a game board that must be printed before playing.

In the directions the players were instructed to print off said slides in order to play the game. Students create a game narrative, which is presented at the beginning of the game and should be limited to one slide. An example of a narrative is presented in Figure 2.3.



Figure 2.3. A narrative from a homemade PowerPoint game.

Players are given directions on how to play and win the game on a single slide separate from the narrative. An example of a direction slide is shown in Figure 2.4.

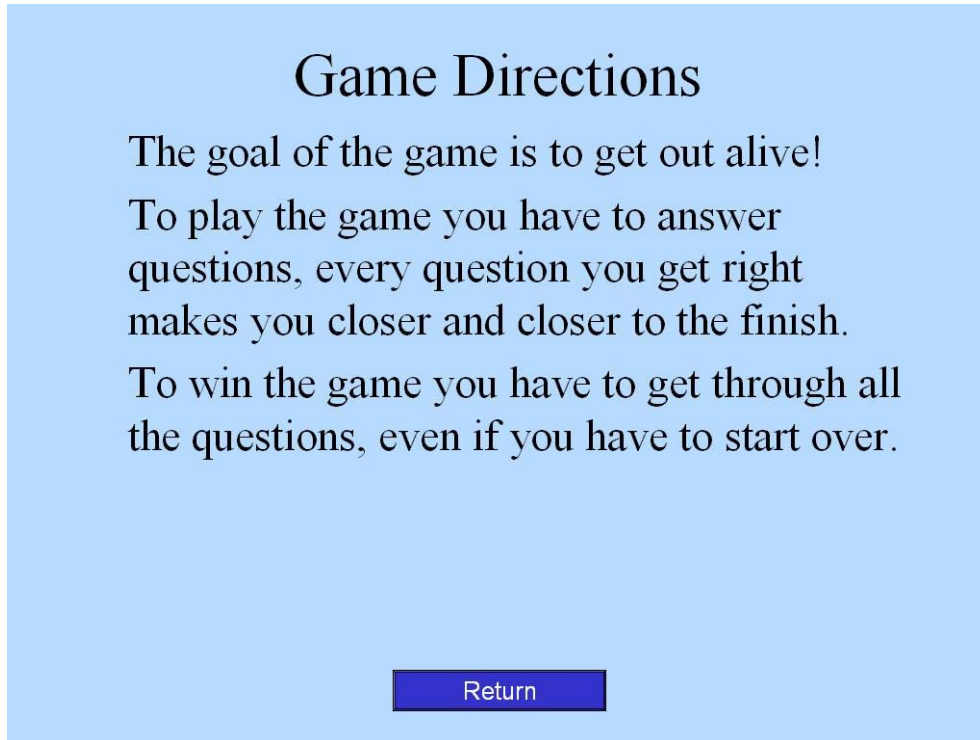


Figure 2.4. A slide containing the directions for a homemade PowerPoint game.

In this particular game, which was created for a unit on materials and natural resources, the players are presented with the scenario of being trapped in a technetium mine and they have to correctly answer the questions in order to find their way out of the mine.

Players navigate through the game by answering multiple choice questions correctly to eventually achieve the goal stated in the narrative (see Figure 2.5).

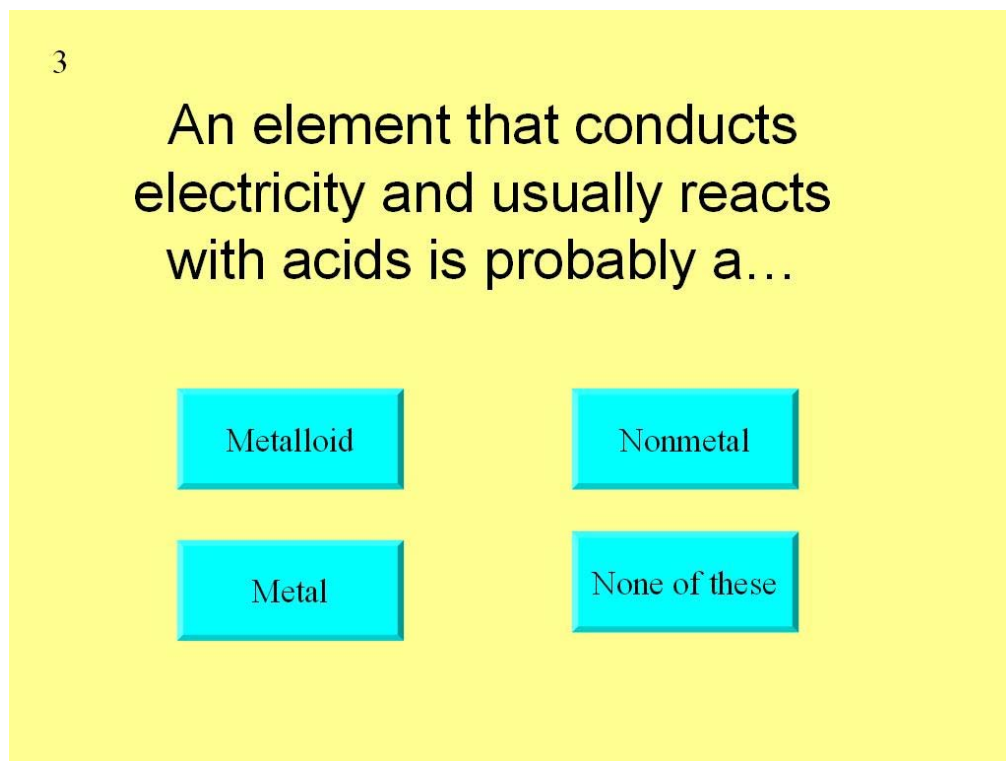


Figure 2.5. A screenshot of a typical multiple choice question.

For this game, students answered questions on properties of the elements. Metals conduct electricity and generally react with acids; therefore, the student would click on the button in the lower left hand corner. Clicking on that button will take a student to a slide acknowledging that the answer was correct, and the player would continue.

Homemade PowerPoint games can be “won” in a variety of ways. Games with external game boards and dice would have a goal of making it to the end of the board. Games with no external parts would include penalties for incorrect answers. Some game would send a player back to the beginning of the game. Other games would incorporate “checkpoints” where players would return if they answered a question incorrectly after reaching a checkpoint. Some games included a scorecard where two players kept track of correct answers or points earned for

answering questions correctly. Finally, some games have clues distributed throughout the game and a final challenge in order to reach the end.

The typical process for implementing a game design project consisted of five consecutive days in the computer lab (Barbour, Rieber, Thomas, & Rauscher, 2009). On the first day, students play various styles of homemade PowerPoint games (i.e., self-contained games and games that required additional materials). After playing the games, the teacher will lead a discussion on what makes a game good and interesting. Generally, students work in groups of two or three for the project. For homework, students begin creating questions for their games and brainstorm ideas for a game narrative. A typical game consists of ten questions per group member, so most games generally have 20-30 questions. On the second day, students usually receive instructions on how to download the template as well as how to create action buttons in *MS PowerPoint*. While students are often very familiar with viewing and creating presentations using *MS PowerPoint*, action buttons are often a feature students have never used. For the rest of the second day and continuing into the third and fourth days, students have time during class to construct their games. When students complete their games, they play their own games to look for errors. On the last day any students still not finished complete their games, while the groups that are finished played each other's games. Shortly after the game project is completed, an assessment of the content is taken.

Research involving Homemade PowerPoint Games

To date, many studies using homemade PowerPoint games as a review tool have not shown statistically significant differences in student performance between control and treatment groups. For example, in a study using homemade PowerPoint games to teach grammar to middle

school students, Parker (2004) did show that students who created games showed increases in their scores between the pre-test and post-test, but the control group showed greater gains. By simply examining the scores without the context of previous student performance, one would have considered the games as a detriment. However, Parker noted that the control group, who normally outperformed the treatment group, actually scored lower on the pre-test compared to their previous performance in the class. Thus, their gains appeared greater than the group who created the games. As for the merits of creating the games, Parker stated the students in the treatment group scored higher on the post-test than their class average or scores on previous assessments would have predicted. The average for the treatment group as a whole was a near failing grade on previous assessments yet achieved a passing grade on the post-test. Parker concluded that the games improved student motivation for the students.

There have been several studies about the use of homemade PowerPoint games conducted at the secondary level. Barbour, Clesson, and Adams (2011) conducted a study in a British literature class comparing the performance of students who created games as a review exercise versus those who completed a more traditional review. The study showed no statistically significant difference in performance between the groups. However, the authors noted the small sample size (i.e., 15 students in the control group and 20 in the treatment group) as a possible reason for those results. Barbour, Kinsella, and Rieber (2011) conducted a similar study in a U.S. history course that was taught in a blended (i.e., instruction occurred in both face-to-face and through a course management system), where students created a homemade PowerPoint game to review one chapter, but completed a traditional review for the other chapters. Again, the researchers found no statistically significant difference in student

performance on content for which they created games, although the students who did create the games performed slightly better than the control group.

Since one of the justifications for using homemade PowerPoint games as an instructional tool is the premise that students will write higher-order questions, the researchers suggested a lack of higher-order questions as a possible explanation for the no significant difference findings. Barbour et al. (2009) examined the data from the Barbour, Kinsella et al. (2011) study to see if students were indeed writing higher-order questions. They analyzed over 1,900 student questions, and a large majority of them (i.e., 94%) were determined to be “Knowledge” level, with an inter-rater reliability of 97%. Furthermore, none of the questions analyzed were above the “Application” level on Bloom’s Taxonomy.

The largest study involving homemade PowerPoint games to date involved approximately 150 students enrolled in an environmental chemistry course (Siko et al., 2011). Student performance was compared on two separate unit tests. On both unit tests, there was no statistically significant difference in performance. Due to the nature of scheduling at the school where the study occurred, it was also possible see if those who created games twice performed better than those who only created games once for the second assessment. While the group who created games for both units in the study performed better than those who created games for only the second unit, it was still not statistically significant.

Similar to the Barbour et al. (2009) study, Siko (2011) analyzed the student-generated questions from the Siko et al. (2011) study. Two researchers independently coded 625 questions for the first unit test and 661 questions for the second unit, with an inter-rater reliability of 86% and 96%, respectively. The coding revealed that approximately 61% of the questions from the first unit and approximately 67% of the questions from the second unit were “Knowledge” level

questions. While these numbers indicate that students are wrote more higher-order questions than in the Barbour et al. (2009) study, student performance in both studies were the same (i.e., no statistically significant difference between control and treatment). Siko et al. (2011) also posited that the inherent nature of a high school science course versus a social studies course would contain more problem-solving content, and thus students should write more higher-order questions.

Siko and Barbour (2012), in the second iteration of the Siko et al. (2011) study, examined the effectiveness of more structure to the game design assignment. The implementation of the project was different that previous protocols, where the questions, narratives, and games were constructed in the days leading up to the test as a review. Instead, the project was spread out over the entire unit. Fewer days were spent in the computer lab, and most of the work was completed prior to going into the computer lab. For the first unit, students were given guidelines for the number of knowledge, comprehension, and application questions the game could contain (i.e., for a group of two writing a total of 20 questions, ten, five, and five questions, respectively). For the first unit, the control group performed better than the group that created the games, and it was determined to be statistically significant ($p < .05$).

For the second unit, even more structure was provided. Students were given the project at the beginning of the unit. Due dates for drafts of both the narratives and questions were given and, unlike previous iterations, feedback was given to the students. In the protocols for prior studies (i.e., four or five consecutive days in the computer lab), there was little opportunity for the teacher to review and provide feedback for the students. The addition of feedback and revisions was supported by the research of Lotherington and Ronda (2010), along with Rickards and DiVesta (1974). For this unit, the students who created games performed statistically

significantly better than the treatment group ($p < .01$). This was the first statistically significant difference in student performance in favor of students creating the homemade PowerPoint games that has been reported

To date, research involving homemade PowerPoint games has shown no statistical difference in performance when the games were used as a review tool prior to an assessment. In these instances the games were created at the end of a unit where students spent four or five consecutive days in the computer lab learning about the games, receiving instruction on the technical aspects of the games, and then constructing the games. However, when the games were part of a longer unit-long project rather than a review, a statistically significant difference in student performance was found. Research has also examined one of the justifications for the use of the games: student-generated questions. In two separate studies, it was found that students primarily wrote “Knowledge”-level questions.

Justifications for Homemade PowerPoint Games

Published research on homemade PowerPoint games (Barbour, Clesson et al., 2011; Barbour, Kinsella et al., 2011; Parker, 2004) have listed three pedagogical justifications for their use in classrooms. The first justification was that the creation of the games is consistent with constructionist pedagogy, first championed by Seymour Papert (1980). The second justification was the games’ reliance on writing a narrative, which encompasses ideas such as microtheme writing and writing across the curriculum (Ambron, 1987; Garner, 1994). Finally, homemade PowerPoint games involved student-generated question writing (Wong, 1985). The following section describes each of the justifications in detail and provides an overview of the literature.

Constructivism and Constructionism

Constructivism, as a learning theory, stresses learning by building knowledge structures (Papert, 1991). Smith and Ragan (2005) defined three key tenets for constructivist design. First, knowledge is built on experience. Second, learning results from personal interpretation of knowledge. Third, learning is an active process. Good constructivist design principles include opportunities for students to express their opinions, create their own meaning, and share control of the classroom (Richey, Klein, & Tracey, 2011). Further, the role of the instructor in a constructivist learning environment is to act as a guide to help students form connections between previous experiences and new ones. The activities in the environment are relevant and meaningful to the student, and promoter higher-order thinking.

Constructivist learning environments contain principles of discovery learning and active learning, the former involving minimal guidance with no predetermined outcome, and the latter emphasizing higher level interactions with old and new knowledge through higher-order processes (Richey et al., 2011). Constructivist learning environments are often contextualized in real-life situations to increase student motivation, and often contain ill-structured problems that students must define the problem, collaborate with one another, and reflect on their own values in order to solve the problem.

Constructionism is an extension of constructivist pedagogy. Seymour Papert, a student of Piaget, coined the term in his work with students using the *Logo* programming language. The simplest definition of constructionism is “learning by making” (Papert, 1991). As Kafai (2001) noted, young children are inherently good at making games anywhere they are at play, both by modifying existing games and inventing their own. Paraphrasing Piaget, Kafai felt that this construction of games was an effort by children to master their environment and make sense of

the world. At the core of constructionism is a student-generated artifact (Rieber, 2004). The artifact is created as a result of a set of driving questions or activities, and acts as a representation of student cognition that can be shared and critiqued. Questions are ill-structured, and the artifact should represent how the student's thought processes changed over time.

Papert's seminal work about constructionism and the programming language *Logo* was *Mindstorms*. The main purpose of *Logo* was to control a small box on the screen (called a "turtle") through commands in the program to create geometric shapes. In *Mindstorms*, Papert (1980) was weary of the computer being used to teach the child, which was the dominant use of computers in education at the time in the form of computer-assisted instruction. Papert felt that it should be the other way around, where the child teaches the computer through programming. In this process, the student was building their knowledge through debugging the program. Papert equated this process as being similar to how a child learns their native language with relative ease, yet struggles through the traditional process of learning additional languages later in life. Papert (1987) went on to illustrate how computer programming through *Logo* helped to teach mathematical problem-solving and geometry, particularly with students who struggled in a traditional math classroom.

Constructionism in Game Design

Kafai, Ching, and Marshall (1997) examined student learning by building astronomy resources for younger children. Fifth and sixth-grade students created astronomy games for younger students using *Logo*. The 26 students worked in groups of three or four to design a game that was to be played by students in the fourth grade revolving around answering a question about an astronomy topic (e.g., "What is the Big Bang?"). The students who designed

the games showed statistically significant gains between the pre-test and post-test in both astronomy and *Logo*. However, *Logo*, with its simplistic layout, is unfortunately no longer flashy enough to compete with today's games (Overmars, 2004). Teaching with *Logo* still persists, and there are annual practitioner conferences around the world, and recent publications on *Logo* tend to be more for practitioner-focused.

Efforts in game design research have tried to create programming languages that are advanced enough to appeal to today's media consumers but still at a level that students can understand (Resnick, 2009). One example of this is the programming platform entitled *Scratch* (<http://scratch.mit.edu/>). Developed at the Massachusetts Institute of Technology, *Scratch* is an open-source programming language geared toward students age 8-16 that allows them to create stories, games, and art. It is combined with a community of learners that teach and borrow from one another (Resnick, 2009). The purpose of *Scratch* is not to create computer programmers; rather, it is meant to foster twenty-first century skills, such as collaboration, problem solving, and creativity. Resnick noted that students can consume media but are often not proficient at creating media, and thus by teaching students to create media they can increase their digital fluency as well as their computational thinking skills.

Peppler and Kafai (2007) discussed in detail the effects *Scratch* had on students in urban settings with respect to informal learning. They noted that in their research they had seen students drawn toward games and projects that had sufficient demands but were still accessible. Further, users of media were discriminating readers but had trouble verbalizing those characteristics. In other words, young consumers of media know what is good but cannot put those traits into words. Peppler and Kafai found that creating media helps learners to better verbalize (i.e., be vocally critical of) their discrimination of media. With *Scratch*'s online

community, there are opportunities for informal learning as well. Their research in urban settings provided examples of art and games that became teachable moments for topics such as American urban culture and the analysis of media.

In a similar retrospective study, Kafai, Peppler, and Chiu (2007) looked at how programming became part of the culture of their research site – an urban community center called the Clubhouse Design Studio – over time. They noted that while *Logo* was available to the students and teachers, it was rarely used. With the addition of *Scratch* to the Clubhouse Design Studio, the number of programming projects increased overall and the majority of them were created using *Scratch*. The authors listed several reasons for the shift. First, since the mentors at the community center (i.e., undergraduate students) were novices at *Scratch* as well, it generated a learning environment where the mentors and students learned from one another. Second, *Scratch* allowed for media-rich programming where students could manipulate high quality digital images as objects in the *Scratch* environment.

Another study involving the urban community center analyzed the programming acumen of the students over the course of the study (Maloney, Peppler, Kafai, Resnick, & Rusk, 2008). The researchers collected 536 projects and analyzed the programming content for use of concepts such as user interaction, loops, conditional statements, random numbers, variables, communication and synchronization, and Boolean logic. Of the seven categories of programming content, five showed statistically significant gains between projects collected during the first and second years of the project, indicating a growth in the ability of students to design more advanced projects. Moreover, the students did not relate their actions to computer programming, with some actually giving the researchers a quizzical look when asked what computer programming was. The researchers indicated that the students used terms such as

“cool” or “fun,” not realizing that what they were doing was indeed computer science. However, some students did see the career potential if they continued to excel in game and media design.

Another programming language, *Alice* (<http://www.alice.org/>), is a 3-D environment that also allows students to create games and digital stories. As their website notes, it features a drag-and-drop interface that creates “a more engaging, less frustrating first programming experience” (Carnegie Mellon University, 2011, ¶ 1). Sung, Shirley, and Rosenberg (2007) discussed the enhancement of a college computer graphics course with *Alice*. While the original intent of the course was computer graphics, many students mistook the class for a game design course; and as a result the course was modified to meet all of the computer graphics objectives while students designed games for the course. The researchers noted that despite an increased workload and little time dedicated to the programming aspects of the course, student attitudes regarding the workload remained unchanged, and the projects created by the students contained richer graphical environments than in previous semesters of the course that did not use *Alice*.

Alice has also been used to increase the knowledge of computer programming concepts among non-computer science majors. Bishop-Clark, Courte, Evans, and Howard (2007) examined three areas (i.e., knowledge, enjoyment, and confidence levels) with students who were not computer science majors using *Alice* in a university setting. In a survey of 154 students, which also include pretest and posttest data, students showed significant gains in all three categories after completing a series of tutorials about *Alice* and two programming exercises. *Alice* has also been used at the K-12 level. For example, Rodger et al. (2010), while teaching *Alice* at the university level for years, have begun efforts to infuse *Alice* into elementary school curriculum. The authors detailed efforts to provide training to elementary teachers by providing summer workshops, tutorials, quiz templates and technical support to hundreds of

teachers. These efforts have been similar to the original *Logo* trainings with summer workshops for teachers (Logo Foundation, 2000).

A key component to constructivist and constructionist techniques is finding the appropriate level of structure to the lessons. On one hand, several studies have shown that constructivist teaching methods are not superior to guided methods of instruction. Kirschner, Sweller, and Clark's (2006) review of constructivist and project-based learning concluded that guided instruction is overwhelmingly superior to methods that provide minimal guidance. In addition, according to what was then current knowledge of cognition and information processing, it was detrimental to take novices through a process of application without a solid base of knowledge. Mayer (2004) also pointed out the lack of successes with instruction using minimal guidance methods, specifically citing studies using *Logo*, in his review of constructivist literature. Kurland and Pea (1985) found that students who learned *Logo* under pure discovery conditions could write simple programs, but were never able to write complex programs built of simple, fundamental concepts. Interviews showed that the students had many incorrect assumptions about programming in *Logo*. In a separate study, Pea and Kurland (1984) also found that students with extensive experience in *Logo* were no better on tests of planning than control groups. This was contrary to Papert's assumption that *Logo* taught students how to problem solve. However, these studies were conducted in situations where *Logo* was taught in a pure discovery format. Mayer (2004) did find that students who were given extensive training in *Logo* were able to outperform students who learned *Logo* under pure discovery conditions, but failed to mention any results that compared those students to a control group who received no training in *Logo*. Mayer concluded by saying that guided instruction in *Logo* is a prerequisite for

transfer, and that Papert was often misunderstood as being a sole proponent of pure discovery learning.

With respect to the actual construction of a homemade PowerPoint game, constructionism can be seen on three levels: the actual *MS PowerPoint* file into a coherent game, the creation of a storyline or narrative for the game, and the construction of the questions themselves. As stated earlier, the purpose for using *MS PowerPoint* as the vehicle to construct the game is to limit the amount of technical acumen needed to implement constructionism. Both teachers and students have a working knowledge of how to use the program. Similarly, the second philosophical justification for creating games, the writing of the narrative or storyline, relies on simplicity as well.

Narratives

The second justification for the use of homemade PowerPoint games in the classroom is the aspect of writing a narrative for the game. Many games have a story that is embedded in the rules and objectives of the game. For example, the game of *Monopoly*® employs the narrative of competing real estate barons whose goal is to own as much property as possible and to force the others into bankruptcy. Narratives are written in everyday language, unlike the unfamiliar language of scientific texts or edu-speak (Avraamidou & Osborne, 2009). This mysterious language is believed to alienate students; therefore, it is believed that science education should make a move toward writing in the everyday language contained in books, movies, and television (Prain & Hand, 1996). By extension, this also could include designing games around a science fiction storyline.

Gough (1993) believed that science fiction could serve as an avenue for helping students grasp the social context of science. Science fiction is often set in the future, and the stories told provide a way of describing how the characters arrived at that point in time. Working backwards to the present, students can begin to grasp how the events of today shape tomorrow, providing meaning to the content by showing how it will directly influence their future. Jang (2009) examined how technology and writing affected student motivation in a seventh-grade science class. The students were allowed to foster real-life examples of content being covered (e.g., dieting and weight management during a nutrition unit). Using qualitative methods, the researcher found the ability for students to create their own meaningful context for content increased motivation, problem-solving skills, and creativity. The study also concluded that creativity did not occur on its own; the environment needed to be highly structured to achieve optimal creativity. Pickens and Eick (2009) also noted increased interest in more inquiry-based assignments for lower achieving students.

Further, Glynn and Muth (1994) discussed the importance of writing as an instructional tool in science. Metacognitive processes involving retrieval, organization, and writing skills force students to work with new knowledge and existing schema. When given a writing assignment, students must consider all of these in addition to the audience for which the writing assignment is intended. However, studies involving writing across the curriculum have not been overwhelmingly convincing. In a meta-analysis of 48 writing across the curriculum studies, Bangert-Drowns, Hurley, and Wilkinson (2004) found only a small but positive impact in achievement from the implementation of such strategies. They found that using the strategies in the appropriate context was beneficial, and that strategies using metacognitive prompts showed enhanced effects. The authors also found the length of the writing assignment reduced the

effects of the strategy. The last finding was applicable to games, as the narratives for games are not lengthy (Dickey, 2006). Game designers do not want players to spend inordinate amounts of time reading; they simply want you to get the gist of the game and start playing as quickly as possible. In the example given above for *Monopoly*®, the narrative can either be found on the box itself or in a small handout. This style of condensed writing assignments, where ideas are written as concisely as possible, is consistent with the type of writing required by microthemes (Stewart, Myers, & Culley, 2010).

Ambron (1987) stated that the difference between note-taking and various narrative-based writing assignments (i.e., journals and microthemes) was that the latter involved an active engagement in the content. Collins (2000) compared the performance of biology students who either completed a series of microtheme assignments or a longer term paper, and found that students who completed more microtheme assignments (i.e., 9-11 assignments) scored 13.2% higher on test scores than those who completed the term paper assignments. Furthermore, Kirpatrick (1984) examined the effects of the use of microthemes in a physics course and also found increased student achievement on tests. Finally, Stanley (1991) and her colleagues noted increased motivation and participation with the use of microthemes in technology courses offered at community colleges. A theme consistent in all three studies was the notion of dispelling myths that writing strategies are solely for English courses.

Garner (1994) examined the use of microthemes in a college accounting class. He noted that writing across the curriculum was useful to help in the active engagement of students, and believed microthemes helped students create a structured and focused argument due to the microtheme's limited space. Anecdotal evidence indicated assignment grades rose from almost all low grades to very few low grades. Teacher evaluation scores also rose, and 80% of the

students voted that the use of microthemes should remain as part of the curriculum. Stewart, Myers, and Culley (2010) conducted a study using a microtheme writing strategy in a women's psychology course. Throughout the semester the treatment group was given several short, unannounced microtheme writing assignments during class time, while the control group did not. Near the end of the semester both groups were given an assessment consisting of multiple-choice questions and an essay that was similar to the microtheme assignments given to the treatment group. The group who wrote microthemes scored statistically significantly higher on both portions of the test than the control group.

In summary, the use of short writing exercises in subject areas other than English language arts has been shown to be an effective tool for increasing both student performance and motivation. Proponents of homemade PowerPoint games stated that the storyline of the game is an example of a microtheme narrative, since it is limited to the space on a single *MS PowerPoint* slide. The final philosophical justification, constructing questions for the game, requires students to consider many variables. Yet, similar to microthemes, questions need to be revised and reworded to be as clear as possible. In the next section, we look at research involving the use of student-generated questions as an instructional strategy.

Question Writing

The final philosophical justification for using homemade PowerPoint games as an instructional strategy is the act of providing challenge to the game by writing relevant questions based on the material (Barbour, Kromrei et al., 2009). In addition, the students must come up with several choices. The students must obviously have the correct option, but they must also create plausible yet incorrect options as distracters. The students are learning what is incorrect as

well as reinforcing the correct answer. The process of developing questions, choosing a correct answer, and developing plausible incorrect alternatives forces the students to analyze the content, even addressing their own misconceptions about the material. Chin and Osborne (2008) stated that there were four reasons for students to write questions in science:

- “direct their learning and drive knowledge constructions;
- foster discussion and debate, thereby enhancing the quality of discourse and classroom talk;
- help them to self-evaluate and monitor their understanding; and
- increase their motivation and interest in a topic by arousing their epistemic curiosity” (p. 3).

Wong (1985), in reviewing 27 studies using self-questioning techniques, gave three theoretical justifications for using self-generated questions as an instructional strategy. First, self-questioning was a form of active processing, which helped learners guide their thinking. Second, self-questioning was supported by metacognitive principles, where students became self-aware of their current level of understanding. Third, schema theory supported the use of self-questioning, since questioning was a way to integrate new information with current schema. Wong found the majority of these studies did enhance learning. However, the results were not overwhelmingly convincing, since there were studies that showed no difference in performance and a few that showed negative results. Upon further examination, Wong determined the level of direct instruction on how to write questions, goals involving more higher-order questions, and the amount of processing time given were all key factors in more successful studies. Wong’s findings were also supported by Rosenshine, Meister, and Chapman (1996), who found that

reading comprehension generally increased when question writing was used as a comprehension strategy.

Lotherington and Ronda (2010) conducted a study involving fourth-grade students creating online board games for geography content. They found that students wrote better questions over time when given the opportunity to not only revise their questions, but to help edit the questions of other classmates as well. Based on classroom observations, the authors found the children to be excited and engaged throughout the project. Harper, Etkina, and Lin (2003) examined question-generating interventions in an introductory physics course. Over a period of eight weeks, students generated questions based on the physics content, and these questions were rated based on the level of difficulty. Roughly half of the questions written by students were rated as low difficulty, while the other half of the questions were rated as being of medium or high difficulty. Test scores showed no relationship between student performance and the number of questions written. However, a significant relationship was found between student learning and the number of conceptually difficult questions written.

Conversely, a similar study by Berry and Chew (2008) examined student performance in an introductory psychology course over three exams and found no relationship between question difficulty and performance. When these authors compared the groups who wrote questions versus those who did not, they found the group writing questions made significant gains in performance over the course of the three exams. In other words, the students writing questions were performing at a lower level earlier in the semester but had erased those differences by the end of the semester. The authors noted a potential reason for the differences in findings between their study and the Harper et al. (2003) study with respect to question difficulty could be the content in the introductory courses. In other words, an introductory physics course may require

more higher-order thinking skills than an introductory psychology course. An introductory psychology course may require more factual knowledge than analytical skills. Thus, students who wrote more difficult questions were better prepared for the assessments in the physics course, whereas analytical skills were not emphasized in the introductory psychology course.

Chin and Osborne (2008), in their literature review of question generation in science, found several common themes. They stated that the nature of the questioning in classrooms has evolved over time from factual exercises to socio-cultural and inquiry-based questions. In addition, the skill needed to be explicitly taught to the students, through scaffolds, prompts, and modeling. While they stated the strategy could lead to positive outcomes, it was ultimately the responsibility of the teacher to foster an environment of inquiry. Herring (2010) provided support for the latter from his qualitative study of question generation at three Australian secondary schools. Further, Herring found a generally favorable attitude toward the technique; however, small pockets of students did not find question generation helpful. With respect to transferring the technique to other courses and for future use, transferring the technique was more of a function of school culture rather than the techniques themselves.

Question writing has been shown to be an effective instructional strategy. There are differing views on whether the quality (i.e., level of difficulty), the quantity of questions written, or both have a greater effect on student performance (Berry & Chew, 2008; Harper et al., 2003). However, there is general agreement that the effectiveness of the strategy can be enhanced through practice, feedback, and scaffolding. The primary challenge in a homemade PowerPoint game is to answer questions created by the designer. The designer must pay attention not only to the construction of the question and the correct answer, but also the alternative choices (Barbour,

Rieber et al., 2009). This process should be supported by teacher through modeling and feedback (Lotherington & Ronda, 2010).

In this section we have reviewed the three justifications for the use of homemade PowerPoint games in the classroom. Constructionist philosophy promotes learning through the building of the homemade PowerPoint game. Writing the narrative or game story gives students an opportunity to demonstrate their knowledge in short, concise writing exercises. Question generation to provide the appropriate level of challenge to their games allows students to develop their understanding through the demonstrating their knowledge of what is correct as well as what is incorrect. The support for these justifications was generally positive but not overwhelmingly so. In the next section we will look specifically at how these findings related the justifications for using homemade PowerPoint games are reflected in the studies examining the games themselves.

Discussion

Given the research involving the justifications for the use of homemade PowerPoint games in the classroom, it would seem that researchers would have little difficulty seeing significant findings in studies examining the implementation of a game project in the classroom. Therefore, we need to question how well the justifications align in practice in the studies examining homemade PowerPoint games.

With respect to constructionism, Siko et al. (2011) first suggested that the game projects, used as a review exercise, did not constitute constructionism. On one hand, the students did create an artifact representing their knowledge. In theory, however, the students would have already learned all of the content through other instructional methods; the game was solely a

reinforcement tool applied immediately before the students were given an assessment. Siko and Barbour (2012), in the second iteration of the study, altered the implementation of the game project away from a review tool to a project that extended through the entire unit. This change, along with others (i.e., corrective feedback, revisions, requirements on question difficulty), may have led to the only statistically significant finding in any of the research examining homemade PowerPoint games.

In the studies examining narratives, researchers found that writing about science could affect motivation (Jang, 2009), and these motivating effects could be seen in lower achieving students (Pickens & Eick, 2009). Parker (2004) suggested that these effects could be seen in lower performing students who created homemade PowerPoint games. However, researchers have yet to examine the effects of homemade PowerPoint games on lower achieving students.

In terms of student performance, the review conducted by Bangert-Drowns et al. (2004) only found a small, positive change in achievement from writing across the curriculum strategies. And while studies examining microthemes have shown increased achievement when the technique is used (Collins, 2000; Kirkpatrick & Pittendrigh, 1984; Stewart et al., 2010), these microtheme assignments dealt with writing about the content. There is a difference between writing a narrative for a game (i.e., fiction) and writing a concise answer to a question posed by an instructor about the content. If a homemade PowerPoint game contained a narrative extrinsic to the content, the justification does not stand. However, Siko and Barbour (2012) addressed this issue by requiring students to relate their story to a content-specific narrative so that the story fostered questions related to scientific processes and inquiry. Even if the game had a narrative which was somewhat related to the content being covered in the course, rewriting and revising the narrative was not the same as answering a specific question related to the course objectives

within a defined word limit. Further, when the games were used as a review tool over the course of several days in the computer lab, one could question how many times the narrative was revised. Finally, Collins (2000), Stewart et al. (2010), and Garner (1994) all examined the effects of microthemes when they were used multiple times throughout a course. Thus, the effects of one short writing assignment (i.e., the narrative), which may be related to the content, on student test performance should be scrutinized.

The task of writing questions for homemade PowerPoint games also contained gaps in the relationship between the research involving the strategy and how it was implemented in the research examining the effects of games. Once again, literature reviews on this strategy showed small, albeit positive effects (Rosenshine et al., 1996; Wong, 1985). Studies involving question writing included opportunities for revisions and review (Lotherington & Ronda, 2010); however, when the games were used as a review tool, there was no time for teacher feedback on the questions. Similarly, the review by Chin and Osborne (2008) found that question writing skills needed explicit instruction, scaffolds, prompts, and modeling in order to be effective, and this was simply not possible over the course of several consecutive days in the lab to start and finish the game design project. Once the game design project shifted from a review exercise to a unit project, which allowed for significant instruction on question writing, test scores revealed a statistically significant finding (Siko & Barbour, 2011).

Finally, one could begin to question whether the homemade PowerPoint games are indeed games. As stated in the introduction, Aldrich (2005) noted that games have challenges and built-in inefficiencies that are both motivating and entertaining. Both Siko et al. (2011) and Siko and Barbour (2012) lamented that the games created in their studies often had narratives that were extrinsic to the content, and that the games rarely referred back to the narrative once

the players began to answer questions. Therefore, it could be said that games with extrinsic narratives could not be considered games, as the challenge of answering multiple-choice questions without a theme, narrative, challenge, or any built-in inefficiencies was nothing more than a digital worksheet with feedback tacked on to a short story.

In summary, based on the justifications set forth by researchers examining homemade PowerPoint games should yield small, positive effects on student learning. However, the justifications as implemented in the research examining the effects of homemade PowerPoint games on student performance were suspect. It was questionable whether the games actually constituted constructionism because the games were often created as a review tool. The narrative research and research examining microthemes dealt with actually writing about the content. If the game's narrative was not intrinsically and explicitly linked to the content, then the justification should not be warranted. The research involving question writing as an instructional strategy showed only minimal gains in student performance which could be enhanced through such practices as opportunities for student revisions, peer review and feedback, and the quality of instruction on how to write good questions. These enhancements were difficult to accomplish when the game project was conducted as a review where students spent consecutive days in the computer lab constructing the games from scratch. Finally, if a homemade PowerPoint game lacked any linkage between the narrative and the questions themselves, it would be difficult to classify the artifact as a game by most definitions.

Future Directions

In this article we have reviewed research involving game design as an instructional strategy, introduced the concept of a homemade PowerPoint game, and examined the

justifications for their use in the classroom. We have also reviewed the current literature on the justifications as well as the research that has been conducted on the use of homemade PowerPoint games as an instructional tool. Many of the findings have shown no statistical difference in performance, and a comparison of the research involving homemade PowerPoint games and the justifications proponents have given for their use has shown two things. First, the literature has shown minimal but positive support for each of the justifications. Second, the recommendations for enhancing the effects of these individual strategies were not present in many of the studies examining the use of homemade PowerPoint games. These two findings may explain the lack of statistically significant findings when comparing test performance between students who created homemade PowerPoint games and those who did not.

Recent changes to how a game design project was implemented, namely an increase in the amount of structure and their implementation as a unit project rather than a unit review, has shown statistical significance (Siko & Barbour, 2012). Therefore, future research should look into whether those changes are responsible for the change in results, and what further changes could be made to further enhance those results. The reason for this finding was attributed to a change in the implementation of the game project (i.e., from a review activity to a unit project and the addition of corrective feedback). Future directions for research using homemade PowerPoint games should look to extend those results by examining reasons why students performed better in those cases.

Siko et al. (2011) first questioned whether the games, as implemented, truly constituted constructionism. The authors wondered whether a review for a test equated to learning by building, as the content had already been presented in a traditional manner. However, in a more structured setting, where the game design project was actually part of the curriculum, the benefits

of constructionist learning might be seen. The aforementioned studies that criticized constructionist practices focused their critique on studies which involved unstructured discovery learning (Kirschner et al., 2006; Kurland & Pea, 1985; Mayer, 2004; Pea & Kurland, 1984), with Mayer (2004) finding that heavily structured constructionist environments outperformed less structured constructionist environments. While the answer may lie with increased structure, researchers should also pay attention to see if the pendulum can swing too far in terms of structure – as one of the motivating aspects of games in education involves the correct level of structure (Hirumi & Stapleton, 2008).

Second, more time needs to be built in for feedback and revision. Students were given assignments to write questions as homework, but they were immediately tasked with constructing the games. Siko et al. (2011) provided anecdotal comments that the students were writing many of their questions in class; therefore, no feedback could be given to the students. Research studies involving student-generated questions mentioned practice and feedback mechanisms for improvement (Lotherington & Ronda, 2010; Rickards & DiVesta, 1974; Rosenshine et al., 1996). In the second iteration of the study (Siko & Barbour, 2012), a structured timeline was provided that included due dates for written questions for which the instructor had time and was able to provide feedback. Also, more instruction and structure was provided to the students with respect to the difficulty level of the questions. Students were given more examples of how to write more difficult questions, such as how to take a “Knowledge”-level question and turn it into a “Comprehension”-level question. One drawback of this approach is that would not allow comparisons to the studies involving the analysis of questions such as the Barbour et al. (2009) and Siko (2011) studies, where questions were written without

difficulty requirements. However, performance on assessments between unstructured and structured groups could be compared.

If logistically possible, students should be given more opportunities to create games. While Siko et al. (2011) and Siko and Barbour (2012) did not see a statistical difference in performance between groups who created games on multiple occasions versus those who only did once or not at all, the group who did create games twice did have a slightly higher score. The authors suggested the difference, albeit not statistically significant, may have been due to an initial discomfort with the new style of instruction. Given a more structured environment, or perhaps more opportunities to create games, is a potential avenue for future research.

Finally, a future direction for research could also be to test the use of narratives as a justification. Student performance could be compared between groups who create their own games versus those that simply write questions that are added to a game with a predetermined narrative, since some studies involving student-generated questions provide benefits without the context of placing the questions within a game or similar artifact (Berry & Chew, 2008; Harper et al., 2003; Rosenshine et al., 1996; Wong, 1985). Taking this one step further, performance between groups who only write questions could be compared to groups who create games, testing the constructionist justification altogether.

CHAPTER 3

DESIGN RESEARCH USING GAME DESIGN AS AN INSTRUCTIONAL STRATEGY

While playing games to learn in school is garnering attention in the media (Prensky, 2010), more and more research is being conducted involving the creation of games as an instructional strategy. The idea of using technology to allow students to create artifacts – such as games – has its roots in constructionist pedagogy, first championed by Seymour Papert (1991). Over the past few decades, computers have been used to create games using programming languages such as *Logo*, *Alice*, and *Scratch* to a wide range of content areas.

However, creating a quality educational game can be difficult. Educational games must compete with traditional games (i.e., games played for leisure) in both graphics and maintaining interest (Squire, 2006). Educational games must also have strong links to educational objectives (Hirumi, Appelman, Rieber, & Van Eck, 2010). In other words, not only must they maintain interest, they must also convey knowledge. The game itself does not do that; it simply provides an environment of built-in inefficiencies that create obstacles that attempt to prevent the player from achieving the goal as a means to challenge and motivate the player (Aldrich, 2005).

In addition, several obstacles exist when using game design to teach topics other than programming. Time can be an issue; teachers need to provide instruction on the programming language in addition to teaching the content (Rice, 2006). Similarly, teachers may not have the technical acumen to appropriately teach the programming language and troubleshoot when difficulties arise (Kafai et al., 2007). Finally, while some of the educational programming languages are open source and free of cost, a school's infrastructure and policies regarding software may still prohibit their use (Barbour et al., 2010). As a result, some researchers have begun to look at “low-tech” ways to apply game-design pedagogy. One way is through the use

of *Microsoft PowerPoint*. While *MS PowerPoint* is clearly not intended as game-design software, it can be used to create simple games. Its ubiquity in school districts clears many of the hurdles involved with installation and support (Barbour et al., 2010), and both students and teachers are for the most part very familiar and comfortable with creating presentations using *MS PowerPoint*.

However, much of the research using these homemade PowerPoint games has shown no statistical difference in student performance between groups of students who created games and those who did not, which has led researchers to question the philosophical justifications for their use (Barbour, Kromrei et al., 2009; Siko et al., 2011). It has also led researchers to examine whether the design and implementation of the game design project can influence student performance. As such, the purpose of this study was to see if altering the implementation of a homemade PowerPoint game project would lead to increased student performance on an assessment when compared to students who did not create the games.

In this article, we will provide a description of homemade PowerPoint games, review the justifications for the use of homemade PowerPoint games, and review the existing research involving the use of the games in K-12 classrooms. We will then discuss changes made to the implementation of the homemade PowerPoint game project based on previous iterations of this study and detail any differences in student performance based on those changes. Finally, we will examine the implications of those changes to the implementation, and discuss further research that still needs to be conducted.

Literature Review

In order to provide some context for the study, we begin with a description of homemade PowerPoint games, followed by a review of the justifications for their use as an instructional strategy, and concluding with a review of the existing research on their use. A homemade PowerPoint game can be created from a template (e.g., those found at <http://it.coe.uga.edu/wwild/pptgames/PPTgame-template1.ppt>) or from a blank *MS PowerPoint* presentation. The game elements include a narrative, objectives, and a means of going about meeting that objective. Like any good game, a narrative is in essence a short story providing context for the game. In the board game *Clue*®, the storyline revolves around the players as suspects in a murder trying to figure out the details of the crime. An example of a narrative is shown in Figure 3.1.

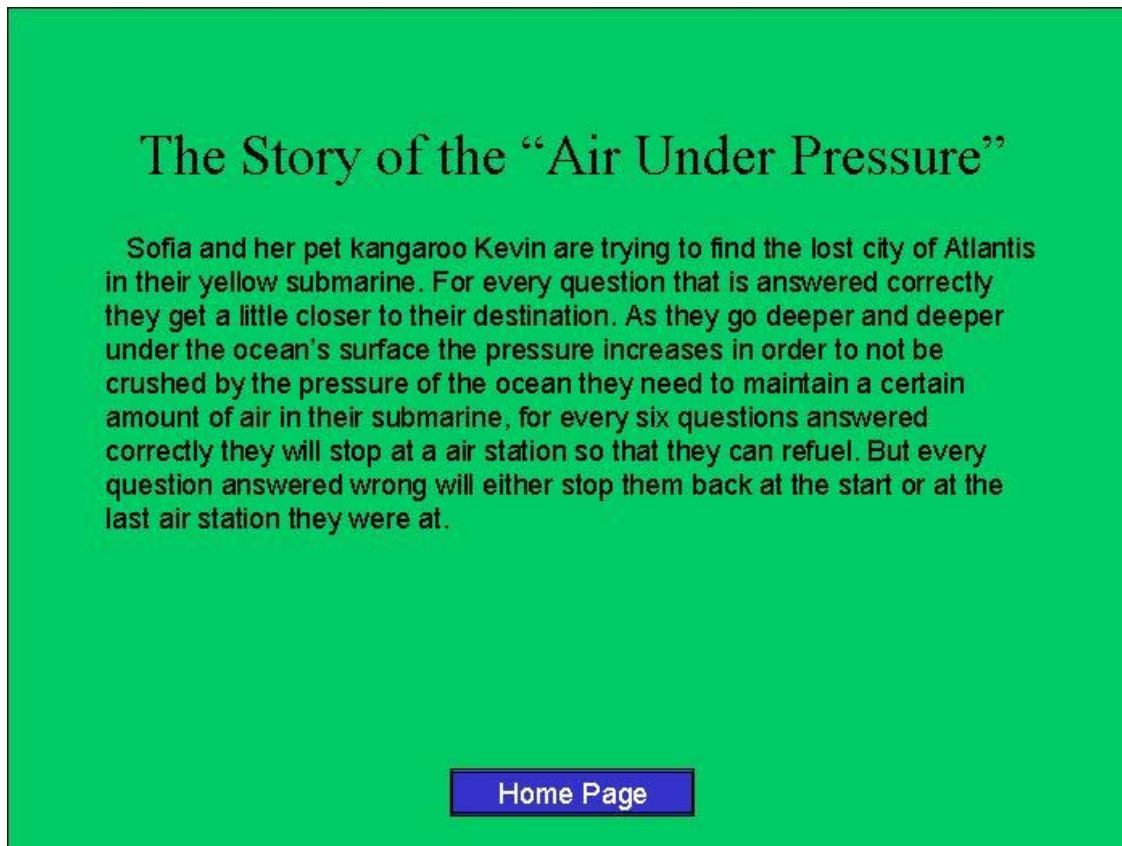


Figure 3.1. An example of a narrative slide in a homemade PowerPoint game.

In a homemade PowerPoint game the narrative must fit on a single *MS PowerPoint* slide. In this example, the players must answer questions correctly to get the characters to their underwater destination.

Players are also given directions on how to play game, which usually involves answering multiple choice questions correctly in order to progress through the game to meet the primary objective (see Figure 3.2). It should be noted that while students have usually elected to use multiple-choice questions to move through the game, this does not have to be the case. Students could also use a “choose your own adventure” model, although this often takes more effort on the student’s part and more class time. So both students and teachers have been reluctant to use this model.

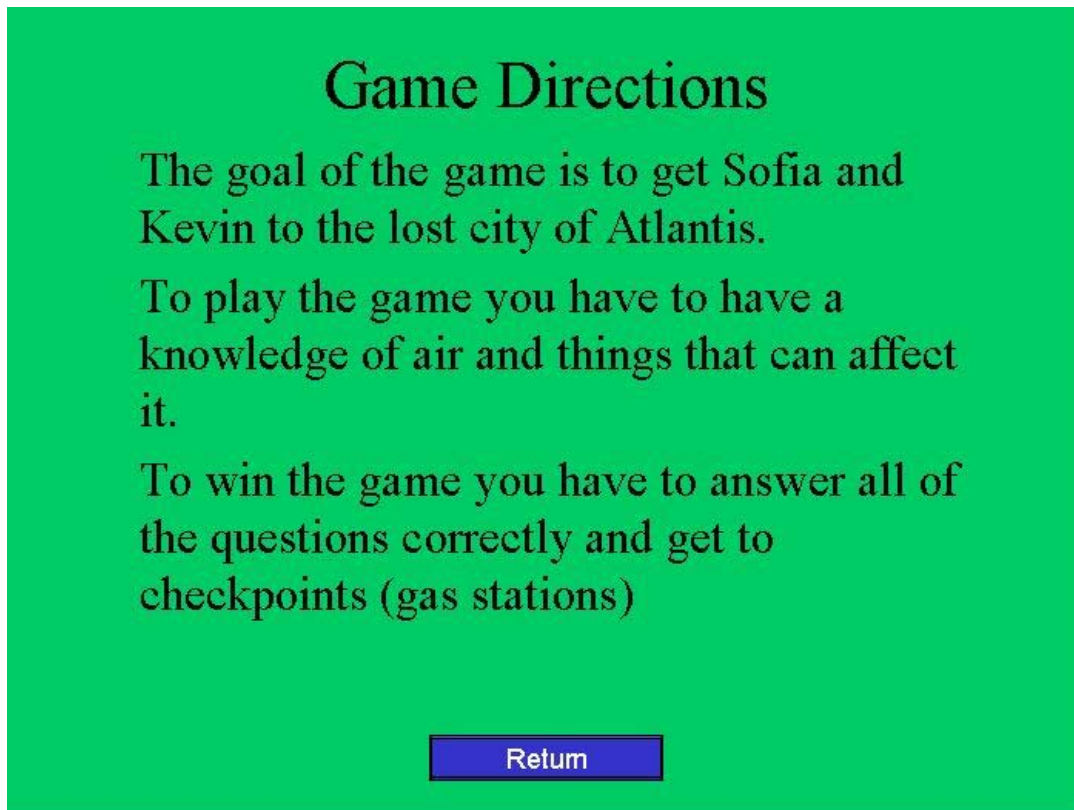


Figure 3.2. An example of a game directions slide in a homemade PowerPoint game.

The directions in this example provide a rough description of how to win the game as well as other features the player may encounter (e.g., checkpoints). The directions may also include a description of what penalties exist for answering questions incorrectly. The game itself can be contained within the *MS PowerPoint* file, or the game can have external elements included in the file that need to be printed (e.g., a game board, dice, or playing cards). In this example, the game had no external components.

Students also create these multiple choice questions for the game, which utilize the action button feature in *MS PowerPoint* (e.g., an action button, when pressed, sends you to a different slide in the presentation, not just the next slide). Figure 3.3 shows an example from the same game.

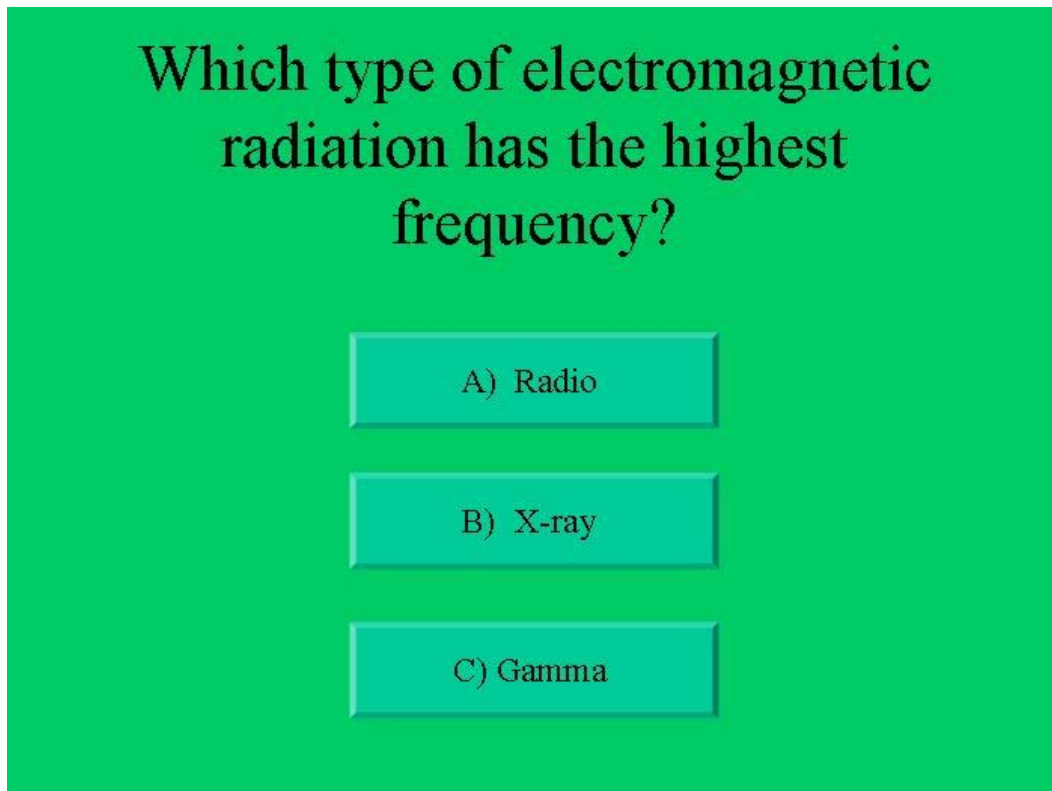


Figure 3.3. An example of a multiple choice question from a homemade PowerPoint game.

In the unit for which this game was create, one of the objectives dealt with the electromagnetic spectrum. Students were required to have a basic knowledge of different types of electromagnetic radiation and how they differed in wavelength, frequency, and energy.

There are three philosophical justifications for the use of homemade PowerPoint games. First, the games are a good example of constructionist pedagogy in practice. Papert (1991) first coined the term constructionism as an extension of constructivist pedagogy where the students learn by building some artifact, which in the case of homemade PowerPoint games is a game. Thus, the students are learning by building an educational game, rather than by simply playing the game. Kafai, Ching, and Marshall (1997) used the programming language *Logo* to create games to teach astronomy content to fifth- and sixth-grade students. They found that students who created games showed statistically significant gains between their pre-test and post-test in both astronomy content and knowledge of *Logo*. Further, Rieber, Luke, and Smith (1998) described game design as a rigorous process of problem-solving that required creativity and collaboration, which can have positive effects on learning and motivation. For example, Sung, Shirley, and Rosenberg (2007), who examined the use of game design to teach computer graphics in a college setting, found that while the game design project required more time from the students than a traditional graphics course, student attitudes remained unchanged concerning the workload. In the realm of science education, Khalili, Sheridan, Williams, Clark, and Stegman (2011) conducted a field study examining how game design was used to teach high school students concepts in immunology. They found that game design helps students to identify gaps in their knowledge, provide a sense of ownership of one's learning, and articulate their knowledge through the construction of the game.

The second justification for the use of homemade PowerPoint games is the writing of the narrative. Students creating games need to provide the context for the game in a concise manner. This condensed style of writing is consistent with the writing required by microthemes (Ambron, 1987), which have been shown to be an effective tool for improving student performance in a number of subject areas, but particularly in the sciences (Collins, 2000). Microthemes allow for the student to take the content and give it personal meaning, which helps to remove some of the apprehension around academic texts (Avraamidou & Osborne, 2009). Writing also allows students to be creative in subject areas, such as science, and allow them to grasp the social context of science (Gough, 1993). In a meta-analysis of 48 studies using writing in other curricular areas, Bangert-Drowns, Hurley, and Wilkinson (2004) found that while the effects of writing strategies were small, the effects could be enhanced through the use of metacognitive prompts and reducing the overall length of the writing assignment. Both of these attributes can be found in homemade PowerPoint games, since the narrative is limited in size and the background of a game orients the purpose of the designer.

Moreover, good educational games have a narrative intertwined with the content (Kenny & Gunter, 2011; Rieber et al., 1998), unlike extraneous themes which simply provide a short story and present a task (e.g., “defeat the wizard by answering 20 questions correctly!”). Kafai, Franke, Shih, and Ching (1998) examined game design processes for teaching fractions to fifth-grade students. The students created games about fractions that were designed to be played by younger children. Their qualitative analysis show that as the groups were given structure to their assignment (i.e., asking students to refine their games without asking a specific question about fractions), the student moved from creating games where the questions were extrinsic to the

theme (e.g., *Jeopardy!*®) to more intrinsic and constructivist games (e.g., cut a pizza and then describe how much is left in fraction form).

The final justification for the use of homemade PowerPoint games is the instructional strategy of students generating questions based on the content. Chin and Osborne (2008) gave four reasons why this strategy was beneficial: it helps direct the student learning, fosters discussion, monitors understanding, and increases motivation. Further, Wong (1985) gave three theoretical justifications for the strategy based on her review of 27 question-generating studies: question generation was a form of active processing, it was supported by metacognitive principles, and it incorporated facets of schema theory. Wong also found that the effects of the strategy were enhanced by increasing the amount of direct instruction on how to write questions and by having goals set that fostered the writing of more higher-order questions. Studies by both Chin and Osborne (2008) and Herring (2010) supported the notion that increased structure (e.g., scaffolds, prompts, modeling) led to increased effects on performance. Additionally, Harper, Etkina, and Lin (2003), who examined the effects of the technique in an introductory physics course, found that while the number of questions written by students was not correlated with performance, the number of quality questions was correlated with performance. Lotherington and Ronda (2010) also studied the use of student-generated questions in a fourth-grade geography class and found students wrote better questions over time when given feedback, the opportunity to revise, and the opportunity to see and edit the questions of classmates. Finally, Kafai et al. (1998), in the aforementioned study examining fifth-grade students designing games, found that with guidance students shifted from providing punitive feedback (i.e., simply stating a player answered a question incorrectly) to providing more corrective feedback (i.e., the game provided reasons why an answer was incorrect).

While the justifications for the use of homemade PowerPoint games in a classroom have empirical support, the research on the use of the games has shown little, if any, significant impact on learning and student performance. The first published study involving homemade PowerPoint games centered on the teaching of grammar to middle school students (Parker, 2004). While the students who created games did increase their scores between the pre-test and post-test, the students in the control group showed greater gains and scored higher on the post-test. In defense of the games, the author noted that the students who created games were generally lower performing students, and their scores on the post-test were higher than their class average would have typically predicted (i.e., the students who created games normally achieved failing grades on assessments and their class average for the test where they created games was average compared to the other students). Parker further suggested that the games could be used as a motivational tool for low-performing students.

Barbour, Clesson, and Adams (2011) conducted a study using games as a review tool for a British literature class. Students in the control group reviewed for the test in a traditional manner while students in the treatment group created homemade PowerPoint games to prepare for the test. The researchers found no statistically significant difference between the groups, although they noted the sample size (i.e., 20 students in the treatment group and 15 students in the control group) as a potential methodological issue with the study. While the games did not statistically improve performance, the authors suggested that the games did not hinder performance, either. Barbour, Kinsella, and Rieber (2011) conducted a similar study in a U.S. history course in a blended environment (i.e., the course had elements of both online and face-to-face instruction) with approximately 50 students. Again, there was no statistical difference in

performance when the games were used to review; however, scores were slightly higher when the students did create the games.

Siko et al. (2011) examined the use of games in a high school environmental chemistry class. Students created games for two separate units: one on resources and materials and the other on air quality and gas laws. For both units, there was no statistical difference in performance. Furthermore, the researchers wanted to see if the students who created games for both units performed better on the second unit test than those who created games for the second unit only or not at all. In other words, they wanted to see if practice or exposure to the technique had an effect on performance. While the group who created games for both units scored higher than the other groups, that difference was not statistically significant.

Due to the repeated lack of statistical differences in these studies, researchers have begun to examine the games more closely. Barbour et al. (2009) tested the assumption that students wrote more higher-order questions by looking at the questions created for the games in the Barbour et al. (2011) study. In their analysis of over 1,900 questions, they found that almost all of the questions (i.e., 94%) were “knowledge” level questions, the lowest level on Bloom’s Taxonomy. None of the questions written were above the “application” level on the taxonomy. Siko (under review) had similar results when examining the questions written in the Siko et al. (2011) study. Students wrote fewer “knowledge” level questions than in the Barbour et al. (2009) study (i.e., 61% for the first unit and 67% for the second unit, respectively). Still, the majority of the questions were factual recall questions, and in the end the test data from both studies showed no statistical difference in performance. Siko (2011) also analyzed the level of questions written by students on the second test based on their level of experience with writing questions (i.e., did students who created games on two occasions write more higher order

questions than those who only did created games on one occasion). The students who created games twice did write more higher-order questions, but the difference was not statistically significant. Siko et al. (2011) and Siko and Barbour (2012) also criticized a lack of opportunity for revision and feedback for student-generated questions, which Lotherington and Ronda (2010) noted as a crucial component of the strategy.

Aside from the justification of question-writing, there has been some criticism of the other two justifications, not only in the general literature but also within the research involving homemade PowerPoint games. Siko et al. (2011) noted that students began to write outlandish narratives rather than those related to content. This was consistent with Kenny and Gunter (2011), who criticized the “save the princess model.” Essentially, there is a potential for lowered interest and motivation to learn the more disconnected the narrative is from the content. Regarding constructionist pedagogy, literature reviews by both Kirschner, Sweller, and Clark (2006) and Mayer (2004) have shown that guided methods of instruction were superior to minimally guided learning techniques (such as game design), although Mayer did acknowledge that highly structured constructivist environments can improve learning. Furthermore, Siko et al (2011) questioned whether the homemade PowerPoint game projects, as implemented in their study and in previous studies, met the definition of constructionism since the games were used to review for an assessment, rather than being used for the initial learning of the content.

In this review, we have introduced homemade PowerPoint games and reviewed empirical research for the three justifications for their use. In spite of these justifications, there is little empirical support for the use of these games in a classroom environment, and that has led researchers to question these justifications. Thus, a new line of research involving homemade PowerPoint games should involve adding more structure to the game project. Elements of the

structure could include opportunities for feedback, games being created as a unit project rather than a review tool, requirements for question difficulty (i.e., guidelines for the level of Bloom's Taxonomy), and the interrelatedness of the game's narrative to the content.

Methodology

This study was the second iteration of a multi-year, design-based research project. The results of the first iteration were reported in Siko et al. (2011). As such, we had similar research questions for this study; however, since the first iteration viewed the homemade PowerPoint games strictly as a review tool the research questions have been slightly altered:

1. Do students who created homemade PowerPoint games as a unit project perform better on multiple-choice tests than students who did not create games?
2. Do students who have created homemade PowerPoint games on more than one occasion perform better than those who have only constructed games once or the control group?

For each of the two research questions, we have developed the following hypotheses:

H₀: No different in student performance.

H₁: A positive difference in performance for those creating homemade PowerPoint games.

For the first unit, which covered material on natural resources and mining, the implementation varied significantly from the protocol in the first iteration (Siko et al., 2011). The review consisted of four consecutive days in the computer lab, where students were introduced to the game, wrote narratives, wrote questions, and built the games, followed by a test. The implementation for the first unit in this study saw computer lab time limited to three

nonconsecutive days over two weeks preceding the unit test. The students were introduced to the project and given time to write questions and narratives in the classroom. The rationale for the change was based on the critique given by Siko et al. (2011), where the authors discussed time off-task in the lab as a practical issue for teachers who wished to use the game project. In addition, critiques of constructionist pedagogy showed a lack of support for discovery learning in constructionist settings (Kirschner et al., 2006; Mayer, 2004), with Mayer pointing out the more structured approaches have yielded positive results. Another difference was a requirement for the number of questions, as students could have no more than ten knowledge-level questions, and at least five comprehension and five application questions.

For the second unit, which covered material on gas laws and the atmosphere, the project was introduced at the beginning of the unit. The teacher and students co-created a timeline of due dates for drafts of the narratives and questions. The rationale for this change was influenced by the studies conducted by Rosenshine, Meister, and Chapman (1996) and Lotherington and Ronda (2010), which found that feedback and revisions were important aspects of improving student learning through question-writing strategies. The students were given three days in the computer lab throughout the unit; one at about the midpoint of the unit, and two consecutive days immediately preceding the unit test. The student questions were due prior to the days in the lab to ensure that students were not using computer lab time to actually create their questions. As with the first unit, students were shown examples of homemade PowerPoint games, and were allowed to play games as a class while in the classroom and (as opposed to the computer lab). However, for the second unit, a rubric detailing all of the requirements and guidelines (i.e., fill-in spots for due dates, question requirements, and requirements for the narratives) was provided to the students at the beginning of the unit. Students were given the additional requirement of

providing corrective rather than punitive feedback for their questions (i.e., if a player answered a question incorrectly, they were told specifically what was wrong with their answer, rather than just being informed that they were incorrect). Figure 3.4 shows a question slide and a slide corresponding to one of the incorrect choices. The purpose of this change was to force students to not only determine the correct response, but to think like the test builder by coming up with more plausible alternatives.

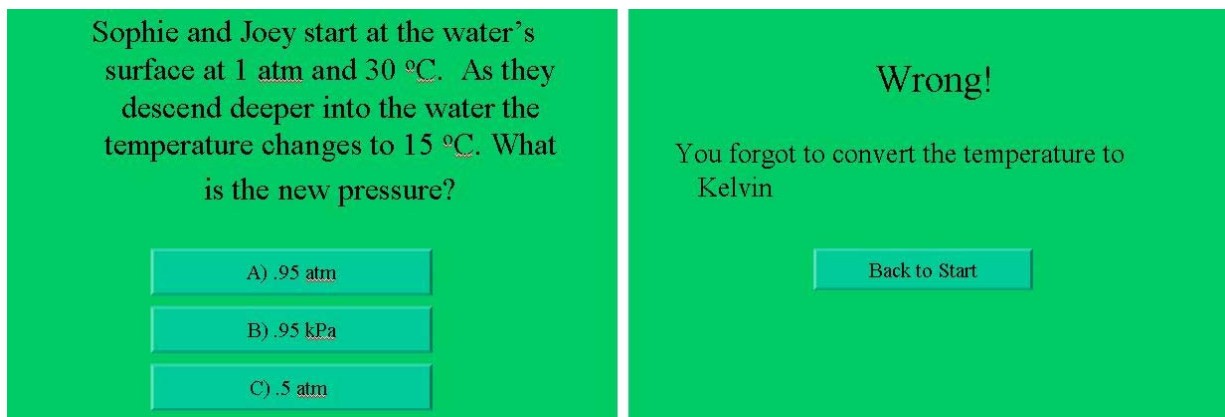


Figure 3.4. An example of corrective feedback for choice C, an incorrect answer.

The rationale for this change was based on the findings of Kafai et al. (1998), which showed a shift in how students provided feedback over time. Since this change affected the workload (i.e., the students needed slides for every choice, not just one for the correct and one for all of the incorrect choices), the students were told that they only needed three choices for every questions (i.e., one correct and two incorrect choices) instead of four choices. Finally, in order to answer the second research question, students could only work in homogenous groups (i.e., both students in a group either made games for the first unit or both students were making games for the first time).

Instruments and Analysis

The instruments used for both unit tests were validated as a part of the Siko et al. (2011) study, where questions for the instrument were selected based on a difficulty index and a discrimination index. All of the questions in the instrument had a difficulty index between .70 and .90, and all of the questions had a positive discrimination value. For the difficulty index, the researchers wanted questions that were not too easy or too difficult. For the discrimination index, a positive value indicated that more high-achieving students answered the question correctly than the low-achieving group (i.e., if the value is negative, it means that more low-achieving students answered the question correctly, which is counterintuitive and may indicate a problem with the question itself). The instruments for each unit consisted of 40 multiple choice questions. Multiple choice tests were used over constructed response questions as a matter of efficiency, and precision gains in measuring achievement when compared to constructed response tests have been shown to be minimal (Lukhele, Thissen, & Wainer, 1994).

An independent t-test compared the results of the group that created games to the group that did not. The test was carried out for both unit tests. On the second test, a one-way analysis of variance (ANOVA) was conducted to see if there were any differences in performance between the group that created games on both occasions versus those who only created games on one occasion and the control group.

Participants and Setting

The research setting for this study was the same large, suburban, Midwestern high school used by Siko et al. (2011). The study was conducted during the 2010-2011 school year. The

school contained approximately 2,000 students, and while the majority of the students (i.e., over 90%) were Caucasian, the district has seen an increase in the diversity of the students over the past decade, especially English language learners. The socioeconomic makeup of the district was primarily middle-class, although all ranges of the socioeconomic spectrum were represented. The school had approximately 100 teachers, and the average teacher had over 10 years of experience.

The course used in the study, entitled Environmental Chemistry, was based off of the *Chemistry in the Community* (also called *ChemCom*) curriculum, which was developed by the American Chemical Society in the late 1980's (American Chemical Society, 2008). Environmental Chemistry was touted as an applied chemistry course where students learn about the chemistry involved in everyday life. The course had a significant lab component and was considered less intensive with respect to calculations and theory. The math prerequisite for Environmental Chemistry was completion of Algebra I, as compared to a concurrent enrollment in Algebra II for the traditional chemistry course. The course was generally considered as an option for college-bound students who were interested in science but who were not planning on a career in science. In reality, however, the course was usually selected by students who had a low interest in science and who were looking for the easiest class possible to meet the requisite number of science courses in order to graduate.

The school utilized a trimester system that consisted of three, 12-week trimesters. Under a trimester system, courses which normally lasted the entire year under a semester system were completed in only two trimesters. Students could have a course over two consecutive trimesters (i.e., the first and second trimester, or the second and third trimester) or have a gap in the middle

of the course (i.e., the first and third trimester). It was not required that a student have the same teacher for both halves of a course.

There were 12 sections of Environmental Chemistry, six of the first half and six of the second half. Two teachers taught the course, and the course was offered over all three trimesters. Table 3.1 shows the breakdown of the course by section, group, teacher, and number of subjects.

Table 3.1

Distribution of Control and Treatment Groups Among Teachers A & B

Trimester	Unit 1		Unit 2	
	Treatment	Control	Treatment	Control
1 st	A – 3 sections (N = 77)	B – 3 Sections (N = 62)		
2 nd				B – 2 sections (N = 52)
3 rd			A – 2 sections (N = 45)	B – 2 sections (N = 47)

Due to limitations in the data collection, along with the variation in how students were scheduled, we were unable to assess if there was any teacher effect. However, when comparing the overall grade for the entire trimester, students in the control group had an overall higher course average than students in the treatment group. This difference was statistically significant ($p < .01$). For the second trimester, the students in the treatment group had a higher course average, but this difference was not statistically significant ($p = .65$).

Results

To answer the first research question, an independent t-test compared the results of the students who created homemade PowerPoint games and students who did not (see Table 3.2).

Table 3.2

Comparison of Test Scores Between Control and Treatment Groups for the first Unit

Group	<i>N</i>	<i>M</i>	<i>SD</i>
Control	62	30.26	5.52
Treatment	77	27.95	6.14

The students in the control group on average received a higher score on the instrument than the group who created games. The difference was determined to be statistically significant, $t(137) = 2.306$; $p = .023$.

On the second unit test, the group who created homemade PowerPoint games scored higher than the treatment group (see Table 3.3). The difference was also determined to be statistically significant, $t(142) = 2.936$, $p = .004$.

Table 3.3

Comparison of Test Scores Between Control and Treatment Groups for the second Unit

Group	<i>N</i>	<i>M</i>	<i>SD</i>
Control	99	23.92	4.86
Treatment	45	26.53	5.16

To answer the second question, a one-way ANOVA compared scores within the treatment group. Students who created homemade PowerPoint games on both occasions in the study scored higher than students who only created games for the second unit, who in turn scored higher than the control (see Table 3.4). The difference was determined to be statistically significant, $F(2,143) = 4.29, p = .016$.

Table 3.4

Comparison of Air Unit Test Scores Between Students who Made Games Twice, Once, or Never

Group	<i>N</i>	<i>M</i>	<i>SD</i>
2nd time with games	22	26.68	4.17
1st time with games	23	26.39	6.04
Control	99	23.92	4.86

Post hoc comparisons were conducted to further examine the differences between the three groups using separate independent *t*-tests. The difference in performance between the students who created games on both occasions and students who only created games once was not statistically significant, $t(43) = .187; p = .853$. The differences between both treatment subgroups (i.e., students who created games twice and those who created games once) and the control were determined to be statistically significant between the control group and the group who created games for both units, $t(119) = 2.47; p = .015$, and between the control and the group who only created games for only the second unit, $t(120) = 2.09; p = .038$.

In summary, the control group performed statistically better than the treatment group on the first unit test, while the reverse was true for the second unit test. When we compared scores on the second unit test based on the number of times the students had created games, an ANOVA also showed a statistically significant difference between the control, the treatment group who only created games once, and the group who created games for both units. Post hoc comparisons showed that these differences were between the treatment subgroups and the control population, not between the subgroups of the treatment population.

Discussion

This study produced two novel results with respect to comparing the performance of students who created homemade PowerPoint games and those who did not. The prior studies have all shown no statistically significant results (Barbour, Clesson et al., 2011; Barbour, Kinsella et al., 2011; Parker, 2004; Siko et al., 2011), which led researchers to suggest that the games were as good as traditional review techniques. The operative word in the prior studies was the term review, as Siko et al. (2011) wondered whether a review could actually be considered constructionism. This study involved the use of the games not as a review but as a learning tool throughout the unit; hence, comparisons between this study and the previous studies, even the study which took place in the same course, should be scrutinized.

In this study, we have a result showing that the control performed statistically better than the treatment, as well as a result which showed the students creating the games performed statistically better than the control. Aside from the content, one major difference was the makeup of the treatment group in the two parts of this study. In the first unit, the entire treatment group had not been previously exposed to the game design strategy. In the second unit, about

one-half of the group had participated in the first unit test; for the other half, it was their first experience. The authors of the Siko et al. (2011) study suggested an initial discomfort with the technique as a possible reason that the scores for the treatment group were lower (albeit not statistically different) than the control group. While one could make the same argument for the statistically significant difference on the first unit of this test, we see that is not the case for the second unit. If it were, the group who created games for the first time on the second unit would not have performed statistically significantly better than the control, as demonstrated by the post hoc comparisons. Collins (2000) found that more practice with microthemes led to improved performance, but this study found no statistical difference on the second unit between students who created games twice versus the group who only created games once.

It should also be noted that while students were randomly placed into sections of the course at the time of scheduling, the assumption that students in the control and treatment groups were of equal ability could be challenged. Looking at the grades at the end of the trimester, students in the control group for the first unit had a statistically higher average grade than the treatment group. Thus, it could be implied that the students in the control group should have performed better on the test. However, for the second unit, where the treatment group performed statistically higher, the grades at the end of the trimester were not statistically different. A separate study by Siko (under review) on the first unit results found that the performance on the tests taken prior to the test in the first unit of this study were the only significant predictors of performance on the first unit test.

Another potential reason for the difference in results between the two units could be the number of higher order questions written by the students, as suggested by Barbour et al. (2009). While Harper et al. (2003) did find a correlation between the number of higher order questions

and performance, we only see this result on the second unit test. This iteration of the study had specific guidelines for the number of questions written based on difficulty. If students followed the guidelines from the teacher (i.e., where 50% of their questions were recall, 25% were comprehension, and 25% were application), they would have written more higher-order questions than either the Barbour et al. (2011) and the Siko et al. (2011) studies. Further research will attempt to determine how well students followed these guidelines.

From a methodological standpoint, the main difference between the results of the first unit (where the control group scored statistically higher) and the second unit (where the treatment group scored statistically higher) was how the project was implemented over the course of the unit. During the first unit there were few changes with how the project was taught, other than the fact that it was shifted from a review activity to an on-going unit project and students were given minimum requirements for the nature of their questions. However, during the second unit the project had more supports with respect to instruction and feedback. The teacher provided more instruction on how to write multiple choice questions and modeled how a recall question could be transformed into a comprehension or application question. The teacher also modeled how he created distracters for a multiple choice question (e.g., multiply instead of divide variables, forget to convert into proper units). Finally, the overall game design environment was more structured with due dates for drafts of narratives and questions, with teacher feedback provided on both.

The idea of additional structure was supported in the literature for all three philosophical justifications for the use of homemade PowerPoint games. For example, Mayer (2004), in his critique of constructivist practices, did note that gains could be seen when more scaffolds were present. Bangert-Downs et al. (2004) found enhanced effects in writing across the curriculum

strategies when more prompts were provided to the students. Further, Wong (1985) found that more direct instruction on question-generating strategies and goals of writing higher order questions increased the effects of the strategy while Lotherington and Ronda (2010) found that revision and editing were important for the success of question-writing strategies as well. Finally, Kafai et al. (1998) found that with guidance, students created games that were less punitive and more evaluative in their feedback. With the exception of the goals of writing higher-order questions (i.e., guidelines for the number of higher-order question), the second unit contained considerable more structure than the first unit.

While the design change resulted from a call for a better alignment with one of the justifications for the use of the games (i.e., shifting from a review to a unit project), we found for the first time where the control performed statistically better than the treatment group. As a result, more structure was added to the protocol for how game design was taught for the second unit, and for the first time a group creating homemade PowerPoint games demonstrated a statistically significantly higher result than the control group. Studies examining the three justifications for the use of the games all have some support for increasing the amount of support.

Conclusions and Implications

In this study, we examined the effects of a change to the design and implementation of a project using homemade PowerPoint games. While the change from a review tool to a unit project provided a stronger basis for stating that the games were a form of constructionist pedagogy, the student performance from the first unit test showed that the control group performed statistically better than the group who created games. Previous research on

homemade PowerPoint games could at least make the claim that the games were as good as traditional review techniques; however, in this case, traditional instructional techniques were superior. With the addition of increased structure to how the games were introduced and supported, the second unit scores painted a different picture, with the students who created homemade PowerPoint games showing a positive statistical difference. Similar to the findings from the Siko et al. (2011) study, there was no statistical difference between groups who created games twice versus those who only created them once.

Practitioners wishing to implement a game design project using *MS PowerPoint* should focus on the protocol used in the second unit test. First, the game-design project should be part of the entire unit rather than as a review tool at the end of the unit preceding the test. Second, students and teachers should provide deliberate instruction and set specific due dates for both the narratives and the questions. The narratives should be the first deliverable handed in, and feedback on how well it ties to the content should be provided. Depending on the length of the unit, it would be advisable to break up the deadlines for turning in questions (e.g., students could turn in one-half of the questions in the middle of the unit and the other half toward the end). Again, feedback would need to be provided to the students. Third, a sufficient amount of instruction needs to be provided on how to write questions, how to create plausible distracters, and how to convert a recall question into a comprehension or application question. In particular, science teachers should not only require students to include calculation problems, but also require students to have questions related to laboratory activities (e.g., a question where students must interpret data from a recently completed lab). Finally, make sure that the students have the narrative and most, if not all, of the questions written before the actual game construction begins.

This will ensure that time using the computers is used constructing the game rather than doing things that could have been completed in the classroom or at home.

Future research needs to validate the notion that the differences in the results of this study were due to changes in the protocol (i.e., an increase in structure). In addition, researchers could continue to test the assumptions made for each of the philosophical justifications for the use of homemade PowerPoint games. Comparisons of performance between students who create games with extraneous versus intertwined narratives could be studied. As science standards have shifted their emphasis from *knowing* science to *doing* science, further research could examine how students can promote inquiry through game design, similar to the work of Sheridan, Clark, and Peters (2009). Research should also continue to examine relationships between performance and the types of questions written. Using qualitative methods, student perceptions of the game design project could be collected and analyzed, paying particular attention to variations in perceptions based on the academic abilities of the student to test whether or not the games can be a motivating factor for low-achieving students. Finally, in addition to providing opportunities for feedback, researchers could test whether repetition of the project (i.e., consecutive units rather than once per semester) to see whether the writing ability, question quality, and test performance improves.

CHAPTER 4

TIGHTENING THE REINS: FINDING AN APPROPRIATE LEVEL OF GUIDANCE ON A
GAME DESIGN PROJECT

The use of games as an educational tool has been explored from multiple viewpoints (Hayes et al., 2008). The more popular discussion involves learning through playing games; however, the use of game design (i.e., where students learn by designing or making games) is gaining in popularity (Kafai, 2006). Hayes and Games (2008) listed four models of game design as an instructional tool: to teach computer science, to encourage gender equality in computer science fields, to teach the fundamentals of games themselves (i.e., rules and challenges), and the creation of games in order to teach academic content (i.e., where knowledge of programming is secondary or purposely made easier). It is the latter that is the emphasis of this study, as we have been examining the creation of games using *Microsoft PowerPoint*, a low-tech but ubiquitous tool in classrooms today (Barbour et al., 2010).

Regardless of which purpose game design is intended, the notion of learning by creating a publicly displayed artifact is known as constructionism, which was first championed by Papert (1980) in his book *Mindstorms*. Since then, game design has been used to teach a variety of content areas to students of many different ages (Kafai, 1998; Lotherington & Ronda, 2010; Reynolds & Caperton, 2009; Rieber et al., 1998). Many of these studies have shown that students not only learn by building artifacts, but also learn significantly better than students covering the same content through more traditional classroom activities.

Research examining the use of homemade PowerPoint games has, for the most part, shown no significant difference in performance on assessments between students who created games and those who did not (Barbour, Clesson et al., 2011; Barbour, Kinsella et al., 2011;

Parker, 2004; Siko et al., 2011). Some researchers questioned whether the games actually constituted constructionism as implemented in these studies (Siko et al., 2011), as these previous studies used the games strictly as a tool to review content already covered. In addition, critics of constructionist techniques have shown that these techniques, when used in a pure discovery learning setting, fail to achieve the same level of learning as traditional methods of instruction (Kirschner et al., 2006; Mayer, 2004). However, at least one critic, as well as Papert's response to these critics, have noted the benefits of constructionist techniques when properly scaffolded (Mayer, 2004; Papert, 1987).

Therefore, the issue becomes what is the appropriate level of structure and guidance for a constructionist game design project? This study was the third iteration of a design-based research study involving homemade PowerPoint games in an environmental chemistry classroom. While the first iteration of the study showed no significant difference in performance between students creating games and those who did not (Siko et al., 2011), additional scaffolds added in the second iteration of the study yielded a statistically significant difference in student test performance (Siko & Barbour, 2012). This third iteration, in addition to more refinements to the implementation of the game design project, also examined the individual justifications for the use of homemade PowerPoint games as an instructional tool.

In this article, we begin with a brief description of homemade PowerPoint games, followed by a review of the three justifications for their use as an instructional tool and, finally, a review of previous research examining their use in classroom. We then detail the third iteration of this design-based research study using homemade PowerPoint games in an environmental chemistry class. Finally, we offer advice for practitioners wishing to use the games in a classroom and provide future avenues of research.

Literature Review

While a homemade PowerPoint game can be any game constructed using *MS PowerPoint*, published research examining their use has utilized games created from a template initially designed at the University of Georgia (which can be found at <http://it.coe.uga.edu/wwild/pptgames/>). The template has ready-made slides for students to input the rules for the game, the storyline for the game, educational objectives, and a copyright slide. The game can be contained completely in the file or the designers can create a game that requires external elements, such as a game board, scorecard, or dice. Since many students have had experience using *MS PowerPoint* for presentations, the only technical skill for which they need additional instruction is the action button feature. The students use action buttons as options for the multiple-choice questions they created.

Researchers examining the use of homemade PowerPoint games in the classroom cite three justifications for their use (Barbour, Rieber et al., 2009). First, the games are an example of constructionist pedagogy, and several studies support the notion that this can be an effective instructional strategy (Kafai, 1998; Khalili et al., 2011; Lotherington & Ronda, 2010). Second, the games force students to write about content in a condensed, concise, manner consistent with microthemes. Microthemes have been shown to be an effective writing strategy in the classroom (Kirkpatrick & Pittendrigh, 1984; Schmidt, Parmer, & Javenkoski, 2002). Finally, students must construct questions for the game, and questioning strategies are also considered an effective instructional strategy (Chin & Osborne, 2008; Harper et al., 2003).

Despite these justifications, much of the research examining homemade PowerPoint games have shown no statistical difference in student performance on tests between groups who

created games and those who did not (Barbour, Clesson et al., 2011; Barbour, Kinsella et al., 2011; Parker, 2004; Siko et al., 2011). However, in each of these studies the games were used as a review exercise before a test. Siko et al. (2011) were the first to question whether these review games actually constituted constructionism.

Further, evidence for the three justifications often included additional scaffolds that were not present in the previous studies using homemade PowerPoint games. For example, critics of pure discovery constructivist teaching techniques found no positive evidence supporting the use of unguided techniques (Kirschner et al., 2006; Kurland & Pea, 1985; Mayer, 2004; Pea & Kurland, 1984). However, Mayer (2004) did state that the techniques do show some benefits with added structure. Kafai, Franke, Shih, and Ching (1998), in their research on game design techniques to teach fractions, found that success of the technique hinged on the instructor's attention to the design of the learning experience. Examples of enhancing the design included asking guiding questions and posing challenges. The researchers found that when these elements were added to the instruction (e.g., challenging the students to create a game without asking questions), students began to demonstrate a deeper understanding of the material by bringing outside knowledge to the games rather than an extrinsic theme followed by drill-and-practice.

With respect to the justification of microthemes and narratives, Bangert-Downs, Hurley, and Wilkinson (2004) in their review of 48 studies examining writing strategies, found that writing-across-the-curriculum strategies, while not convincingly positive in their effects, could be enhanced through the addition of metacognitive strategies such as prompts. More importantly, much of the microtheme research used by proponents of homemade PowerPoint games deals with content writing, not fictional writing (i.e., the storyline for a game). In addition, microtheme studies reported increased student achievement when several microtheme

assignments were given throughout a semester (Collins, 2000; Stewart et al., 2010). While Siko et al. (2011) did examine how student performance when they created games on multiple occasions, creating narratives for games does not compare to multiple writing assignments where students attempt to express their knowledge of content.

The lack of repetition is also apparent with homemade PowerPoint game research and the third justification of the process of writing questions as a learning tool. In her review of questioning literature, Wong (1985) – another study often used by homemade PowerPoint game proponents – found that while the effects of questioning strategies on learning were minimal, they could be enhanced through more instruction on how to write higher-order questions and more processing time. Further, Lotherington and Ronda (2010) found that students wrote better questions when they were given time to edit and peer review their questions over time. The previous studies examining homemade PowerPoint games often had students creating narratives, constructing questions, and building the games over a four or five day period preceding a test, allowing little or no time for additional instruction or peer review.

Siko and Barbour (2012) noted these issues and examined the effects of homemade PowerPoint games in a science classroom when they were created as part of a unit project rather than a review. The researchers added several layers of structure to the game project, including additional instruction on question writing, deadlines for drafts and questions with teacher feedback, and requirements for the difficulty of the questions (i.e., minimum numbers of comprehension and application questions). On the first unit test, the control group scored statistically higher than the group who created games. The researchers then added two more requirements. First, the students needed to include corrective feedback for incorrect answers. Second, students were encouraged to tie the questions to the theme of the narratives, rather than

having a short story followed by twenty drill-and-practice problems. On the second unit test, the students who created games performed statistically higher than the control group; the first statistically significant finding in favor of students who created homemade PowerPoint games.

In summary, much of the research examining the effectiveness of homemade PowerPoint games has not been convincing. However, when examining the research on the justifications for their use (i.e., constructionism, microthemes, and question writing), the implementation of the homemade PowerPoint game project often did not match the recommendations made by researchers based on these justifications. When the implementation was better aligned to these justifications there was a statistically significant finding. However, we could still question whether the finding was the result of the game project or due to one or more of the justifications in isolation.

Methodology

The purpose of this study was to compare student performance on a unit assessment between students who create homemade PowerPoint games and those who do not. Also, as the instrument used in this study was consistent with the instrument used in previous rounds of data collection, we also compared student performance between groups who created homemade PowerPoint games as a review, and those who created homemade PowerPoint games with less structure to the assignment (Siko & Barbour, 2012; Siko et al., 2011). Finally, given the justifications for the use of homemade PowerPoint games in the classroom, we also compared student performance on unit assessments between students exposed to an isolated teaching strategy based on those justifications (i.e., microtheme assignments and question writing) and

those who were not. Based on these goals, we developed the following research questions for this round of data collection:

1. Do students who create homemade PowerPoint games as a structured unit project perform better on a unit assessment than students who do not?
2. Do students who create homemade PowerPoint games as a structured unit project perform better on a unit assessment than students who created homemade PowerPoint games as an unstructured unit project?
3. Do students who create homemade PowerPoint games as a structured unit project perform better on a unit assessment than students who create homemade PowerPoint games as a review?
4. Do students who complete microtheme writing assignments perform better on a unit assessment than students who do not?
5. Do students who complete question-writing assignments perform better on a unit assessment than students who do not?

Setting

The school used in all three iterations of the study was a large, suburban, Midwestern high school. Constructed in 1998, the school housed grades ten through twelve and had approximately 2,100 students. The school district covered 54 square miles, which included one village and parts of several surrounding townships. The school district provides services to approximately 8,000 students. There were about 100 faculty members, including teachers, counselors, and social workers. The school generally ranked above both the state and national averages in standardized test scores.

The high school utilized a trimester system. Instead of the traditional semester system where a course ran for the entire year, most courses in the trimester system ran for two of the three trimesters. The two trimesters did not have to be consecutive (i.e., a student could take the course during the first and second trimester, second and third trimester, or the first and third trimester). The school day consisted of five periods, which lasted 72 minutes.

The course used in the study, Environmental Chemistry, was based on the *Chemistry in the Community* curriculum. Also known as *ChemCom*, it was developed by the American Chemical Society (2008). The course was an applied chemistry course, with less emphasis on theory and complex calculations and more content that showed how chemistry concepts were applied to everyday life. The course was currently offered as an elective science class, one that could be applied to the number of science credits required for graduation, but not specifically for the state's physics/chemistry requirement. The course was geared toward a college-bound student who did not plan to major in a science or engineering discipline.

However, the student who was most likely to select Environmental Chemistry did not fit that profile. While the socio-economic distribution in the school district was primarily middle-class and professional, all levels of the economic spectrum were represented in a typical environmental chemistry classroom. Many of the students were not college-bound, with a sizeable number of the students matching the description of being at-risk (Chen & Kaufman, 1997). While the course was an elective course, implying that students would select it based on interest rather than necessity, the common perception among students was that it was the easiest of all the potential elective courses.

The content covered in this study came from the first two units of the *ChemCom* curriculum: Water and Materials. The first two unit tests covered topics such as water quality,

water softening, ionic compounds, and solvation. The third unit test covered topics related to the periodic table, mining, and natural resources.

Data Collection

In order to answer the first three research questions, we used a similar implementation that we did in the second unit of the second iteration of the study (Siko & Barbour, 2012). That is, during the first trimester of the 2011-2012 school year, students created games as part of a structured unit project. During the second trimester, several changes were made in the protocol for the homemade PowerPoint game project. First, the students were given a design challenge partially based on the Materials unit from the *ChemCom* curriculum. In the text, there is a project where students are tasked with creating a coin. Thus, the students were directed to design a game in which the players needed to make decisions about making a coin from start to finish, such as which materials to use, where to mine for the materials, and to also embed content from the unit. Students were given a template to map out their narrative (which can be found at http://www.michigan.gov/documents/mde/ELA_WAC_263481_7.pdf), and were given time to take their questions and rewrite them into the narrative (i.e., to help prevent the drill-and-practice feel of games from previous iterations).

To answer the fourth and fifth research questions, we examined the strategies embedded in a homemade PowerPoint game project in isolation, and compared their effects with the effects of the games themselves to determine whether or not it is the games in their entirety which lead to improvements in student performance or the individual strategies (i.e., microtheme assignments and question writing). We collected data on student performance when students were subjected to several instructional strategies during the second trimester and compared it to

control groups from the first trimester. Table 4.1 summarizes the distribution of control and treatment groups over the two trimesters.

Table 4.1

Distribution of control and treatment groups during each trimester

	Unit 1		Unit 2		Unit 3	
	Microthemes		Question Writing		Game Design	
Trimester	Treatment	Control	Treatment	Control	Treatment	Control
1 st		3 Sections		3 Sections	3 Sections	
2 nd	1 Section		1 Section		1 Section	

In the first unit, the students were given three microtheme writing assignments. During the second unit, the students were given instruction on question writing and assignments where they constructed their own multiple choice questions, and were given three assignments where they wrote multiple choice questions based on each of the provided objectives for the unit. During the third unit, students constructed homemade PowerPoint games similar to the previous iterations of the study.

We created and validated two new assessments in addition to one of the assessments from the previous two iterations of the study (Siko et al., 2011). These three assessments each consisted of 40 multiple-choice questions. The new assessments were administered to three sections of students enrolled in Environmental Chemistry during the first trimester and to one section of Environmental Chemistry during the second trimester.

Data Analysis

The data analysis for this iteration was similar to the first two iterations. During the first trimester, the two new assessments given during the Water unit were validated, while the third unit assessment (i.e., for the Materials unit) had already been validated in the previous iterations. Student performance on the third assessment was compared to student performance from the previous years, including groups who created games and those who did not. For the third unit during the second trimester, students created homemade PowerPoint games with changes in from the implementation during the first trimester. Student performance was compared to student performance during the first trimester, as well as previous iterations. Table 4.2 summarizes the comparisons made concerning the different implementations of homemade PowerPoint games.

Table 4.2

Matrix of comparisons between scores on unit three test.

Data from Third Iteration	Comparison Group
1 st Trimester (structured unit project)	Control (all iterations combined)
	Review activity (first iteration)
	Unstructured unit project (second iteration)
2 nd Trimester (structure project with strong link between narrative and questions)	Control (all iterations combined)
	Review activity (first iteration)
	Unstructured unit project (second iteration)
	Structured unit project (third iteration, first trimester)

Because the same instrument was used for this unit in all three iterations of the study, it was possible to compare groups who created homemade PowerPoint games with students who did not, but also students who created games for under different conditions from the previous iterations.

During the second trimester, we also examined the justifications for homemade PowerPoint games individually. For the first unit, students were given instruction on how to write microthemes and they completed three microtheme assignments. Student performance on the assessment for the first unit was compared to a control group from the first trimester using an independent *t*-test. For the second unit, students were given instruction on constructing multiple-choice questions and completed three assignments where they had to write multiple-choice questions based on the stated objectives for the unit. Their performance on the second unit test was also compared to a control group during the first trimester. Table 4.3 summarizes the comparisons made examining the individual justifications of homemade PowerPoint games.

Table 4.3.

Matrix of comparisons of scores between groups receiving additional instruction on narratives and question writing.

Test and Justification in 2 nd Trimester	Comparison Group from 1 st Trimester
Unit one test (microthemes)	Unit one test (control)
Unit two test (question writing)	Unit two test (control)

Reliability and Validity

Each of the instruments used in all three iterations of the study went through the same process of validation. An initial assessment consisting of 60 questions or 50% more than the desired 40 questions for the instrument was administered to students. We then conducted an item analysis, where we examined the percentage of students that answered each question correctly. We selected questions where between 70% and 90% of the students answered correctly (Linn & Gronlund, 2000), which ensured that the questions were not too difficult or too easy. We also examined the discrimination index for each question, which is a measure of how low achieving students and high achieving students answered each question (Nitko, 2004). Questions with a negative discrimination index were discarded, as a negative result indicated that more low-achieving students answered the question correctly than high-achieving students.

When performing statistical tests involving a *t*-ratio, several assumptions must be made (Runyon, Coleman, & Pittenger, 2000). We assumed the samples being compared were normally distributed around their mean, that groups had similar standard deviations, the individual observations were independent of one another, and the participants for the control and treatment group were selected at random. Siko et al. (2011) stated that although students were not randomly selected to be part of the control or treatment group, course scheduling at the school was somewhat randomized (i.e., every student had an equal chance of being placed in a class that was part of either group). While normality had not been tested in previous iterations, Runyon et al. (2000) stated that large sample sizes (i.e., greater than 25) mitigate deviations from a normal distribution. Sample sizes in all three iterations exceeded that number. Finally, standard deviations had been similar to each other.

Results

To answer the first three research questions, we measured student performance on a test for which the students created homemade PowerPoint games under a variety of conditions (Siko & Barbour, 2012; Siko et al., 2011). Table 4.4 summarizes the results from each of the three iterations of the study.

Table 4.4.

Summary of scores on unit test where students created homemade PowerPoint games for each of the three iterations of the study.

Group	N	Mean	SD
Control (all iterations combined)	163	29.81	5.41
Review activity (first iteration)	62	28.52	5.86
Unstructured unit project (second iteration)	77	27.95	6.14
Structured unit project (third iteration – First Trimester)	78	29.74	6.49
Structured unit project with strong link between questions and narrative (third iteration – Second Trimester)	26	30.12	6.05

The combined control group average was higher than both the review and unstructured unit project group averages. The structured unit project group scored slightly lower than the control group, while the final group (i.e., a structured unit project with a strong link between the questions and the narrative) had the highest average. In order to compare the performance from groups covering all three iterations of the study, independent *t*-tests were used to determine whether each group's score was statistically significantly different from each of the other groups.

Table 4.5 lists the individual comparisons between all of the groups and the resulting p -value from the independent t -tests.

Table 4.5.

Summary of results of t -tests comparing test performance between control group and the iterations of the homemade PowerPoint game project.

Data from Third Iteration	Comparison Group	p -value
1 st Trimester (structured unit project)	Control (all iterations combined)	.93
	Review activity (first iteration)	.25
	Unstructured unit project (second iteration)	.08
2 nd Trimester (structure project with strong link between narrative and questions)	Control (all iterations combined)	.79
	Review activity (first iteration)	.25
	Unstructured unit project (second iteration)	.12
	Structured unit project (third iteration)	.79

From the data in Table 4.5, we see that while both groups who created games in the third iteration of the study performed better on the unit test than either the control group or students who created games in the previous iterations of the study, none of the comparisons were deemed statistically significant.

In order to answer the fourth and fifth research questions, an independent t -test was used to compare test scores between groups that had been given an intervention based on one of the

justifications for the use of homemade PowerPoint games in the classroom. The results from the first unit test, where students were given microtheme assignments, are shown in Table 4.6.

Table 4.6.

Comparison of test scores between control group and group that were given microtheme assignments for the first unit.

Group	N	Mean	SD
Control	82	32.32	5.91
Treatment	23	33.57	4.81

We see that the students who were given microtheme assignments scored higher than the control group. However, these results were determined to not be statistically significant, $t(103) = 0.93$; $p = .35$.

For the second unit, students in the treatment group were given several question writing assignments. As Table 4.7 shows, these students scored better than the group that was not given these additional assignments.

Table 4.7.

Comparison of test scores between control group and group that were given question writing assignments for the second unit.

Group	N	Mean	SD
Control	82	29.87	5.56
Treatment	26	30.50	5.30

However, while the students who were given question writing assignments scored higher than the control group, as with the microtheme assignment the difference was not statistically significant, $t(106) = 0.51$; $p = .61$.

In summary, we set out to determine if changes to the implementation of the homemade PowerPoint game project, namely by providing more structure and guidance in the creation of the game, had any effect on student performance when compared to groups who did not create games and students who created games under different conditions. Further, we also examined the performance of students who were given isolated interventions based on two of the individual justifications for the use of homemade PowerPoint games as an instruction tool. In all of the cases, the additional structure and the use of the interventions in isolation did lead to higher test scores, but none of these differences were shown to be statistically significant.

Discussion

In the first trimester, students creating the games did perform on the test when compared to students who did not create games, and to those students that created games as a review tool or as a project with less structure. However, these results were not statistically significant. In the second trimester, the test scores increased again, but the findings were still not statistically significant. While these results were promising in the sense that the changes in each of the iterations has had a positive effect, the lack of statistical significance relegates the results to the game project simply being as effective as traditional instruction. Siko et al. (2011), in the first iteration of the study, noted that the game project was time consuming and findings that were not statistically significant called into question the practical effectiveness of the strategy. However,

anecdotal statements from the instructor of the course suggested that while many of the students created games where the questions were seamlessly integrated with the narrative of the game, a large number of the games would still qualify as drill-and-practice games (i.e., with the narrative being completely thematically detached from the questions). While stating the effectiveness of games where the content is intrinsic with the narrative, Kafai et al. (1998) only had such results after their students created several games, followed by the students being given such design challenges as creating a game without questions. The amount of practice may be key to the success of a game design project. In both Siko et al. (2011) and Siko and Barbour (2012), when the game project was carried out a second time, scores between the students who designed games on both occasions increased when compared to the control group and to students who were designing games for the first time.

With respect to the two justifications in isolation (i.e., microthemes and question writing), the findings were for the most part, consistent with the literature. Studies examining writing-across-the-curriculum strategies have shown that the effects of these strategies were positive but minimal (Bangert-Drowns et al., 2004; Stewart et al., 2010). Providing shorter writing assignments was shown to be a factor in increasing the effects of the writing assignments; however, while the assignments were limited in length to a paragraph or less, we did not see statistically higher test performance. Practice with the technique was also a factor found to enhance the effects of microtheme assignments (Stewart et al., 2010). One could question whether three writing assignments was sufficient for students to become acclimated to the technique as a way to learn or to gauge their learning.

Similar arguments can be made for the justification of question writing as an instructional tool. The literature has shown that the effects of the technique were minimal but positive (Chin

& Osborne, 2008; Wong, 1985), and we saw higher but not statistically significant scores when the teacher used the technique in this study. Once again, the benefits can be enhanced through practice, feedback, and revision (Lotherington & Ronda, 2010), and one could question whether three assignments constituted sufficient practice to allow the students to become comfortable with the technique. Further, Lotherington and Ronda (2010) noted the importance of peer review and revisions in the question writing process. While the students were given feedback by the teacher on the quality of their questions, they did not receive feedback from their peers – as Lotherington and Ronda promoted. In addition, there were no opportunities to actually revise and resubmit the questions to the teacher. The feedback was meant to be incorporated into the next question writing assignment, but as there was no mechanism to confirm whether students actually used the feedback. If the students had been asked to revise and resubmit each assignment, they would have been forced to take the feedback into account.

Conclusion and Implications

In this study, we examined the effects of not only different implementation methods of a game design project, but also the effects of two of the individual justifications for the use of homemade PowerPoint games as an instructional tool. While the effects for all of the interventions were positive, none of the findings were statistically significant. While the changes made to the implementation of the project did lead to increases in student performance on tests, the lack of significant findings demonstrated the need for further changes to be considered.

For practitioners wishing to implement a homemade PowerPoint game project in their classroom, it is important to consider the following aspects. First, provide opportunities for feedback on both the narrative and the questions and build in as much time as possible for

resubmitting work. This may be necessary in order for students to gain the full benefit of the assignments. Second, provide both guidance and time for students to better integrate the content of the narrative and the questions. While the intention of the design of the third iteration was to better integrate the two, anecdotal evidence suggested otherwise. To date, the only additional change to the implementation which yielded a statistically significant finding was the addition of corrective feedback to the questions (i.e., having the students give feedback to the player why their choice was incorrect).

Future research into the use of homemade PowerPoint games should attempt to replicate this study, as some of the sample sizes were small for some of the comparisons. Also, future research should continue to examine changes made to the implementation of the project. Further enhancements could include more opportunities for practice and revisions to the narrative and the questions. Also, students could be provided with more opportunities for peer review at various stages of the project. Generally speaking, the opportunity for students to play each other's games has been a function of available lab time and the students' abilities to complete the game project before the last available day in the computer lab. Finally, additional research could examine the level of the game's integration of narrative and academic content on individual test performance, as not every game created matched the goals of the changes to the implementation of the game project for this iteration of the study.

CHAPTER 5

GAME DESIGN AS AUTHENTIC SCIENCE: CREATING LOW-TECH GAMES THAT
“DO” SCIENCE

Much attention has been given to the debate over the value of students learning by playing games (Hirumi, 2009). Many agree that students learn by playing games, but they argue over what the students actually learn (Foster & Mishra, 2009)! A different approach entails having students design games as a way to learn content. The problem with game design is that teachers often do not have the time or the expertise to teach computer programming, let alone content and process skills. In addition, installing game design software can create friction between the teaching staff and technology department. If there was only a way to have students create science games without new software or having to bring in the computer science teacher from down the hall.

For the past three years I have been refining a “low-tech” approach to game design that uses a program that can be found in most schools with a computer lab, *Microsoft PowerPoint*. In this article, I will describe a “homemade” PowerPoint game, discuss the justifications for their use, detail the evolution of the game design project in my environmental chemistry classes, and provide tips for teachers interesting in implementing the project in their own classrooms.

What is a Homemade PowerPoint Game?

A homemade PowerPoint game can be created from a blank presentation, but I used a template from the Homemade PowerPoint Game website (which can be found at <http://it.coe.uga.edu/wwild/pptgames/>). Students must create a short yet interesting narrative for their game, as shown in Figure 5.1.

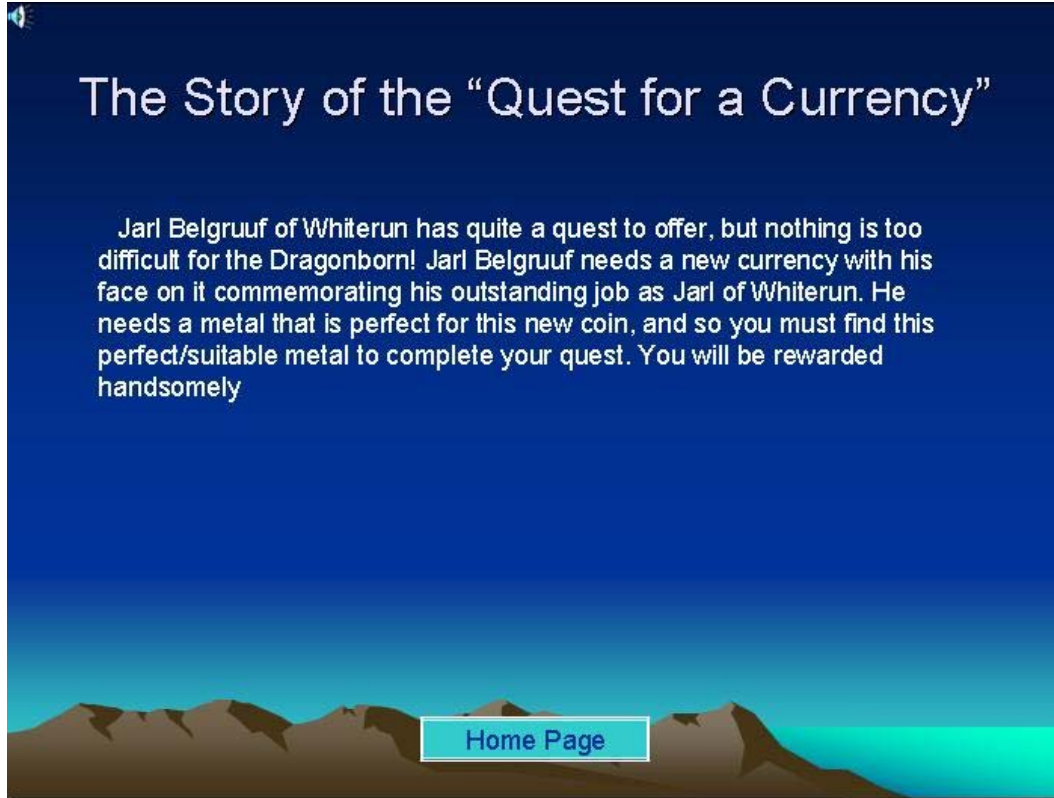


Figure 5.1. An example of a narrative from a homemade PowerPoint game.

Games have rules and objectives, and students must describe how to play and win the game. Both the narrative and rules must be as concise as possible; many commercial board games can print their rules on the back of the box! Students can design the games to be completely contained within a *MS PowerPoint* file, or they can include a game board, score card, dice, and game pieces. If an external game board is required, images of the game board can be pasted onto a slide with directions to print those slides before the game begins. Figure 5.2 shows an example of an instruction slide.

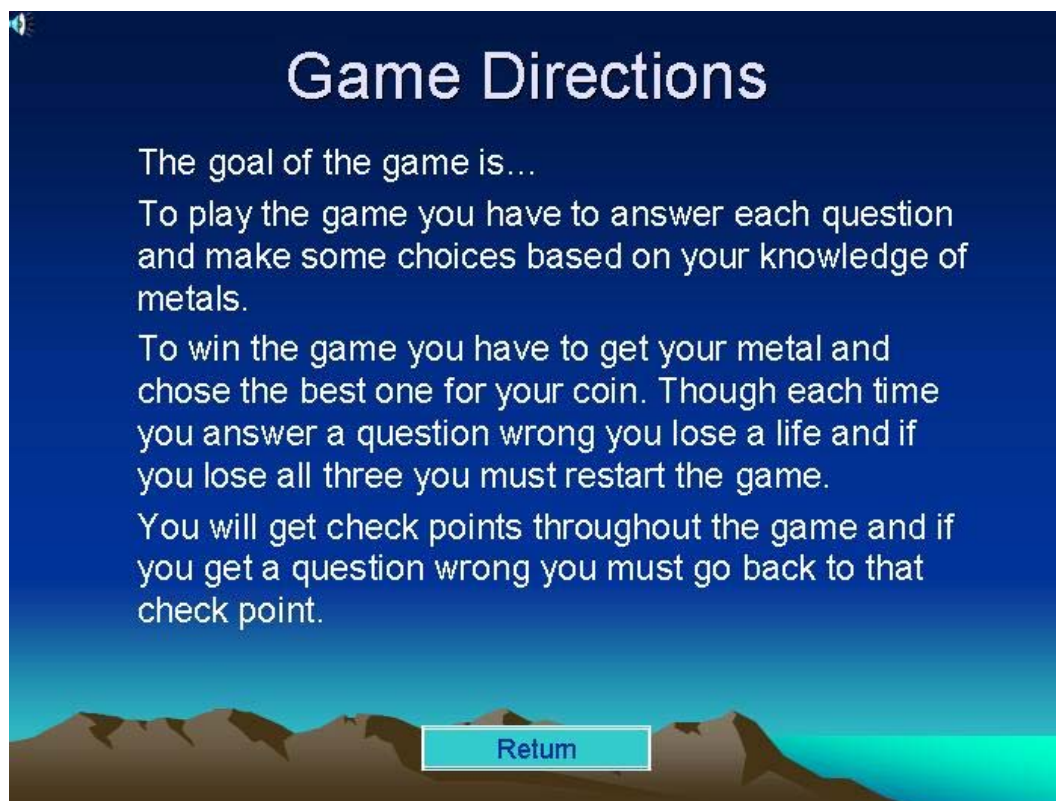


Figure 5.2. A slide stating the rules for the game.

The players often must achieve some goal by correctly answering a series of multiple choice questions. Many students are very comfortable creating presentations using *MS PowerPoint*. However, many are not familiar with creating action buttons: buttons that, when pressed, send the player to a predetermined slide (i.e., rather than always the next slide in the deck). Thus, each choice is an action button that sends students to a slide indicating their choice was correct or incorrect (see Figure 5.3).

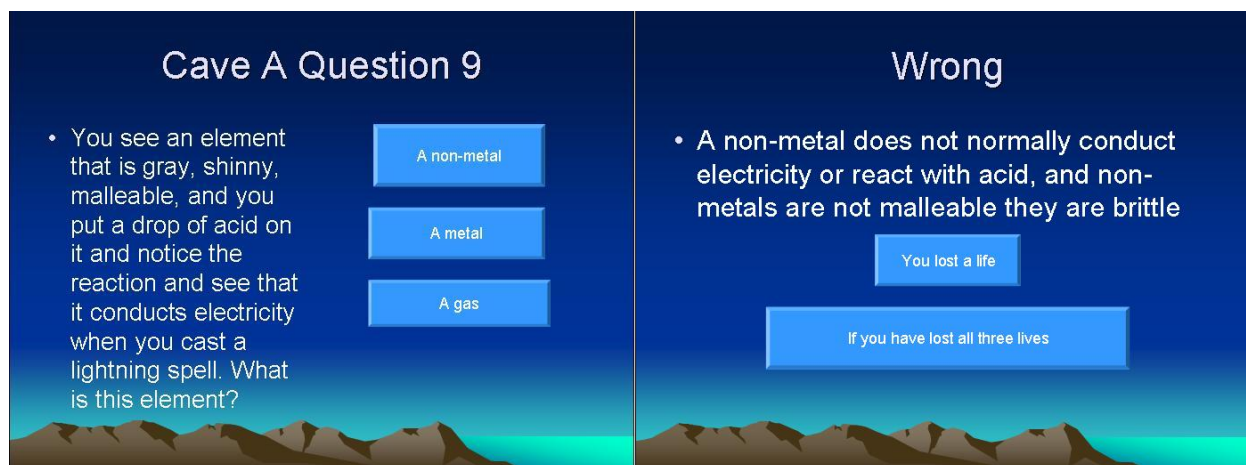


Figure 5.3. An example of a question in a homemade PowerPoint game and the feedback for an incorrect choice.

Why have students create games?

Researchers investigating the benefits of creating games cite three reasons for their use (Barbour et al., 2010). First, “learning by building” is a philosophy known as constructionism, a term first coined by Seymour Papert (1980) and his use of the computer language *Logo* to teach geometry. Second, creating a concise and interesting storylines that are relevant to the science topic, teachers must use both microtheme and writing-across-the-curriculum strategies during the project (Jang, 2009; Stewart et al., 2010). Finally, students must create good questions, choose a correct answer, and develop plausible yet incorrect alternatives (Harper et al., 2003). Question writing is an effective instructional strategy (Lotherington & Ronda, 2010). To make the games interesting, students are asked to increase the difficulty as the game progresses, so they cannot simply write twenty recall or true/false questions.

I began to examine homemade PowerPoint games as an instructional tool in science as part of my doctoral studies. I currently teach a course titled Environmental Chemistry. At our school, this course uses the American Chemical Society’s (2008) *Chemistry in the Community*

textbook, commonly known as *ChemCom*. The first year I implemented the game design project, I replicated the implementation process used by researchers examining homemade PowerPoint games in other subject areas (Barbour, Clesson et al., 2011; Barbour, Kinsella et al., 2011; Parker, 2004), where students created games as a review exercise in lieu of a more traditional review worksheet. The students spent four consecutive days in the computer lab. On the first day, the students were introduced to the game project. We had a discussion on what were some aspects of games that made them interesting. Examples included having a goal, having chance events, and getting progressively more difficult. The students then played several homemade PowerPoint games; some were contained completely within *MS PowerPoint* and some required external pieces such as dice or a game board. After the students chose partners for the project (most of the students worked in groups of two), they were given a homework assignment that asked them to come up with a theme or narrative for the game and to start writing questions for the game.

On the following day, students began constructing their games. As mentioned before, the only programming instruction needed involved teaching students how to create action buttons in *MS PowerPoint*. Almost all of my students had created a presentation using *MS PowerPoint*, but practically no one had used action buttons before. The students also continued to write questions for the game. On the third day, students continued to work on the game. If the group finished their game, they began to debug their game. On the final day of the project, students put the finishing touches on their games, debugged their games, and began to play other groups' games. Playing other games provided them an opportunity to see other games, review for the test, and provide a final layer of testing the games before the final submission. Students took the test the following school day.

While students who created games did just as well as students who did a more traditional review (Siko et al., 2011), it was impractical to spend that much time reviewing to get the same results as a review guide! Looking at the justifications for the use of homemade PowerPoint games, I began to revise the protocol. One question we brought up was whether or not a review exercise constituted constructionism, since the learning supposedly occurred before the game project; the game was simply a way to prepare for the test. Another problem was that the research for both writing narratives and writing questions emphasized improved performance with practice and revision.

As a result, I made several changes to the project the following year. First, the project was no longer a review process held immediately prior to the test; the project would extend throughout the unit. As a result, time could be built in for feedback. Another change that was made was to spend fewer days in the computer lab. In the first year I noticed a fair amount of time off-task due to the fact that only one group member could be working on the *MS PowerPoint* file. It was not absolutely necessary to be in the computer lab to create a narrative or to create questions. Efficient groups would delegate work; one member would type up the questions in *MS Word* while the other worked in *MS PowerPoint*. The questions could be sent via e-mail, and the students took turns copying and pasting the questions into the game. However, since students did not usually have all of their questions done when they arrived in the computer lab, time allocated for constructing the game was spent writing questions, a task that could have been completed without wasting precious lab time.

Second, I required students to tie the theme directly to the narrative. Students were spending too much time creating outlandish narratives and graphics to go along with the narrative. Students were also creating “save the princess” games, where it was clear that the

narrative was never revisited once the students began to play the game. From an interest standpoint, games of this nature were simply drill-and-practice after reading the introductory slides. The narrative needed to be woven through the questions as the player progressed. Finally, I provided more structure with respect to the questions. I included requirements on the number of knowledge, comprehension, and application questions (Bloom, 1956). In addition, I gave them the objectives for each unit at the beginning of the project, stating that they needed to have at least one question tied to every objective.

After the first unit, I saw that students were still not performing better than students who did not create the games. For the second unit, we added another layer of structure. Students needed to include corrective feedback in their games. Before, when a player answered a question incorrectly, they were simply informed that the answer was incorrect. This time around, the students designed the game to not only inform the player that they were incorrect; they had to inform them what was wrong with their choice. For example, in a question that required a calculation (e.g., a question about Boyle's Law), they could be informed that in their choice they multiplied two variables instead of dividing them. After this change was made, students who created games outperformed students who did not (Siko & Barbour, 2012).

Making it Authentic

During this past year, I looked to incorporate science practices into the game. It was nice that students were creating good questions relating to the content of the *ChemCom* curriculum, which emphasizes the National Science Education Standards E and F, which cover science, technology, and society (National Academy of Sciences, 1996). However, the games rarely involved the authentic scientific practices and scientific inquiry stated in the NSES Content

Standard A. I also looked to better integrate the theme into the game itself, as I was not satisfied with how the students' narratives actually fit into the game. In previous years, the games had an extraneous narrative that had nothing to do with science. They tended to be a short story followed by 20 drill-and-practice problems. Was it possible to have students create games where they designed problem-solving experiences for the player, thus deepening their understanding of science processes themselves?

I gave the students a theme to guide their narrative based on the theme in the Materials unit in the *ChemCom* curriculum. While giving them flexibility in their storyline, the game had to deal with the design of a coin. The content in the Materials Unit of the *ChemCom* text covered topics such as physical and chemical properties, redox reactions, layers of the earth, and factors to consider when mining for resources. To help facilitate this integration, I used write-to-learn activities from our state's writing-across-the-curriculum guide (which can be found at www.michigan.gov/documents/mde/ELA_WAC_263481_7.pdf), and provided additional time for rewriting questions to incorporate elements of their story.

As a result, this additional layer of guidance resulted in games where students designed authentic science practices and higher-order problem solving into the games, rather than the drill-and-practice games I saw in previous iterations. I also saw students who were usually not engaged in the class come up with very creative stories that integrated science process skills. The quality of the games as a whole improved tremendously. While students did perform better on the test than students who did not create games as well as groups who created games in previous iterations of the study, those differences were not statistically significant (Siko & Barbour, 2012). However, with the focus of the game project changing drastically over the

course of three years, comparing scores on the same test may no longer be a fair assessment of their science process skills.

Conclusion and Advice

I have been using the homemade PowerPoint game project twice a year for the past three years, and from the revisions I have learned several lessons about implementing a game design project. While my research has focused on using a “low-tech” platform such as *MS PowerPoint*, I feel that the following principles are generalizable to any game design situation:

- the project must last throughout the entire unit and not only as a review tool;
- provide time for instruction on question writing skills;
- allow time for revision, editing, and teacher feedback on narratives and questions;
- if it can be done outside of the computer lab, do it outside of the computer lab;
- create conditions where students are encouraged to integrate the narrative into the game as much as possible (i.e., avoid “save the princess” and drill-and-practice games); and
- give students the objectives as early as possible.

The game project has been well received by students. While students were not enthused when the project was introduced, I was surprised by the creativity of some of the students, especially since the course has a population of disengaged and at-risk students. Using a choose-your-own-adventure model, rather than a drill-and-practice or *Jeopardy*® style game, required more work on the part of the student, but led to more authentic science questioning and problem-solving. While *MS PowerPoint* is not the optimal game design platform, other user-friendly programming

languages (e.g., *Scratch* and *Alice*) could be used if time can be allocated for teaching programming as well as science content. Further, as we progress toward more inquiry-based standards, we will need to design a wide variety of experiences for students to express their ability to perform authentic science practices. Designing a game may be one way to for students to do so.

CHAPTER 6

CONCLUSIONS

This study was a design-based research study that consisted of three iterations, two of which are part of this dissertation. I examined the effects of a homemade PowerPoint game design project on student test performance in an environmental chemistry course. After each iteration, revisions were made to the implementation of the design project with a focus on better aligning the project to the three justifications used by proponents of homemade PowerPoint games.

In Chapter Two, an article entitled, “Game design and homemade PowerPoint games: An examination of the justifications and a review of the research,” I gave an overview of a homemade PowerPoint game, reviewed previous studies involving homemade PowerPoint game, and review the literature supporting the three justifications for the use of the games as an instructional tool (i.e., constructionism, microtheme and narrative writing strategies, and question writing strategies). The outcome of the literature review questioned the alignment between the implementation of the game project in previous studies and the justifications.

In Chapter Three, an article entitled, “Design Research Using Game Design as an Instructional Strategy,” I discussed the second iteration of the study. In this iteration, we made several changes from the first iteration (Siko et al., 2011). First, the game project was changed from a review exercise to a unit project. Second, more structure was added by adding guidelines for question difficulty, and directing students to related the questions to content objectives for the unit. These changes resulted in students in the control group scoring statistically higher than the students who created games on the first unit. For the second unit in the study, students were given additional guidelines. For example, students were required to turn in drafts of their

narratives and questions to allow for teacher feedback. Second, the students were required to provide corrective feedback for incorrect answers to questions in their game. After these changes were made, students who created games scored statistically higher on the test than students in the control group, the first statistically significant finding in favor of students creating homemade PowerPoint games.

In Chapter Four, an article entitled, “Tightening the Reins: Finding an Appropriate Level of Guidance on a Game Design Project,” I detailed the third iteration of the study. In this study, I examined the game project and two of the individual justifications (i.e., question writing and microtheme writing) to see whether these strategies, as opposed to the game project, were responsible for the statistical findings. The protocol for the game project remained the same in the first trimester to see if the findings from the second iteration could be replicated. Unfortunately, the statistically significant finding from the second iteration could not be replicated, although the game design students did perform better than the control group on the unit test. In the second trimester, the game project was refined once again. Students were required to have a narrative which was directly related to a project-based assignment in the course. It was hoped that this design change would shift the games away from a drill-and-practice game, where the narrative was usually an afterthought, to a game where students built in authentic science practices (e.g., data analysis and complex problem solving). While the test scores did increase with these changes, they still were not statistically higher than the cumulative control group students or students who created games under different circumstances in the previous two iterations of the study. Finally, students who were given microtheme assignments and question writing assignments in isolation performed better on tests than students who were also not given these assignments, but those differences were not statistically significant.

In Chapter Five, an article entitled, “Game Design as Authentic Science: Creating Low-Tech Games that ‘Do’ Science,” I provided practitioners with an overview of the evolution of the game design project. In addition, readers who wish to implement a game design project were given a list of recommendations based on the findings and the observations of the classroom teacher over the three iterations of the study.

Limitations of the Study

While design-based research was an appropriate choice for this three-year, iterative study, there was one major drawback to drawing conclusions based on results from test scores in different classes. First, while any student who created a game had the same instructor in each of the three iterations, students in the control groups came from one of three teachers (including the teacher involved with implementing the game design project). Due to the trimester system at the research site, students could also have different teachers for each part of the course and at different times of the year. Therefore, tracking the teacher effect size would have been extremely difficult.

In a similar fashion, a study such as this is quasi-experimental (i.e., where every student has an equal chance of being placed in the control or treatment group). While there was an element of randomness with respect to whether a student had a certain teacher (or teachers) for a course when class scheduling occurred at the school, this study was not a purely randomized study. The assumption that each class will perform about the same as another class, even with the same instructor, was suspect. While Siko et al. (2011) noted that the class averages were very close for the control and treatment groups in the first iteration, additional research conducted during the second iteration found that previous test performance was a better (i.e.,

statistically significant) indicator of test performance on the test for which the students created games. A detailed account of this study can be found in Appendix G.

Finally, in the third iteration of the study, the emphasis of the games shifted slightly from strictly covering content to incorporating aspects of science process skills. While some of the content objectives were process oriented, one could begin to question whether the test used in the study assessed these skills adequately. While using the same test for each iteration of the study allowed me to compare student test performance within and across the three iterations of the study, this shift in emphasis may have affected the validity of the test based on the specific implementation in the third iteration.

Implications for Practitioners

Practitioners in any content area wishing to implement a game design project using homemade PowerPoint games should consider the following recommendations. In addition to other researchers (Hayes & Games, 2008; Kafai et al., 1998), I would add my voice to the suggestions to be explicit in the instructions and pay explicit attention to the design of the overall game design project. However, caution must be exercised so that there is some element of creativity afforded to students for the project. In other words, if every detail of the game design project is predetermined, student motivation will probably decline if they are not allowed any creative input into the game (Kafai et al., 2007). With that said, however, some parameters need to be in place to ensure that the games are focused on the content through a design challenge or driving question. These directives should help to prevent the games from becoming strictly drill-and-practice, at which point the narrative becomes a less motivating factor.

Additional instruction and structure should be given to students on how to write good test questions, how to write a good story, and how to integrate the two. It may be useful to consult with a language arts teacher when designing a game project in another content area (Robertson & Howells, 2008). With respect to questions, it is recommended that the students have ample opportunities to practice writing more difficult questions and time to revise and receive feedback on multiple occasions, either from the instructor or fellow students (Lotherington & Ronda, 2010). As previously noted, a statistically significant finding occurred when these aspects, as well as requiring students to provide (i.e., create and put into the game) corrective feedback for incorrect choices in their games (Kafai et al., 1998).

In terms of logistics, I found it helpful to limit computer lab time to strictly building the game. Students tended to have a better chance of finishing when the primary elements of the game (i.e., the questions and the narratives) were completed and revised well before the games were constructed. This was easily accomplished when the implementation shifted from a review exercise to a unit project.

Finally, one of the practical problems instructors face when deciding to implement a homemade PowerPoint project is time. In other words, almost all of the research has shown that while the games can be as effective as other instructional and review techniques, it is potentially more time consuming (Siko et al., 2011). To alleviate this time problem, common courses could work together to develop the game. For example, a language arts class and a social studies class (i.e., with a common pool of students) could work on a game project from both a content standpoint in social studies and a writing standpoint in the language arts class.

Suggestions for Future Research

Future research examining the use of homemade PowerPoint games should continue to refine the implementation of the project to see if students can score statistically higher on tests as a direct result of creating the games. With respect to the use of the games in science, further changes could examine how students can create and exhibit authentic science practices within games, and whether the creation (and playing) of the games improves science process skills (Sheridan et al., 2009). This would require that the assessments reflect that goal and not a situation where students are tested solely on their content knowledge when constructing a game for the purpose of enhancing process skills.

To date, most if not all of the data collected when examining the use of homemade PowerPoint games in classrooms has been comparative and quantitative (Barbour, Clesson et al., 2011; Barbour, Kinsella et al., 2011; Parker, 2004). Little research has been published with respect to student perspectives on the game design project. One of the reasons why games in general are perceived to be a popular platform is that they are visually stimulating (Kenny & Gunter, 2011). Homemade PowerPoint games are not. An investigation on the motivational aspects of the games, particularly with respect to the creativity afforded students in the narrative and the lack of visual stimulation in the game, would help researchers make changes to the implementation and provide practitioners with information to help them decide whether to utilize *MS PowerPoint* for a game design project.

Finally, as game design software becomes more readily available, affordable, and easier to learn, researchers could examine whether the design principles suggested by this study and others carry to all platforms, such as *Alice* and *Scratch* (Maloney et al., 2008; Rodger, 2010). Further, researchers could examine whether the visual elements of object-oriented programming

languages increase student understanding when constructing games in science involving concepts at microscopic or molecular level (Khalili et al., 2011).

APPENDIX A

WATER SECTION AB TEST

Use the following information to do numbers 1-3.

52.3 64.2 39.8 77.1 98.0 42.3 85.2 14.7

1. Calculate the mean.
 - a. 473.6
 - b. 83.3
 - c. 59.2
 - d. 58.25

2. Calculate the range.
 - a. 473.6
 - b. 83.3
 - c. 59.2
 - d. 58.25

3. Calculate the median.
 - a. 473.6
 - b. 83.3
 - c. 59.2
 - d. 58.25

4. Pure water conducts electricity.
 - a. True
 - b. False

5. What is “grey water”?
 - a. water right out of the faucet
 - b. water that has been used once and could be reused
 - c. toilet water
 - d. distilled water

6. Humans require _____ of water per day.
 - a. 1 cup
 - b. 2 liters
 - c. 50 gallons
 - d. 370 liters

7. Distillation produces very pure water but is seldom used in water treatment plants. Why not?
 - a. distillation is too expensive
 - b. distillation does not remove all contamination
 - c. distillation eventually alters the molecular structure of water
 - d. all of the above

8. The endless cycle of water traveling from land surfaces to oceans to clouds and back to the ground again is called the _____.
 - a. hydration cycle
 - b. hydrologic cycle
 - c. hydropic cycle
 - d. hydrolysis cycle

9. Which of the following are examples of direct water use?
 - a. Cooking
 - b. Drinking
 - c. Flushing the toilet
 - d. all of the above

10. Porous rock structures that are located underground and hold vast amounts of water are called:
 - a. water canyons
 - b. ground water reservoirs
 - c. aquifers
 - d. waterfords

11. What was done to test the purity of the water in the foul water lab?
 - a. conductivity test
 - b. distill the sample
 - c. taste it
 - d. refilter with charcoal

12. What percent of the Earth's surface is covered by water?
 - a. 30
 - b. 50
 - c. 70
 - d. 90

13. Which of the following is a property of water that is not important for life?
 - a. Water's unusually high boiling point
 - b. Water's high surface tension
 - c. Water's solid form is less dense than its liquidform
 - d. Water is tasteless

14. A carefully placed staple will float on water due to water's:
 - a. density
 - b. surface tension
 - c. chemical properties
 - d. mass

For the following mixtures, determine whether they are a
 A. solution B. suspension C. colloid

15. A medicine that says shake before using.

16. salt water (i.e. a teaspoon of salt in a gallon of water)

17. milk

18. mayonnaise

19. Two or more elements that are bonded in a definite proportion form

- a. A mixture
- b. A compound
- c. A colloid
- d. A solution

20. A change in which bonds are broken and new bonds are formed, resulting in new substances being produced is called

- a. Distillation
- b. Filtration
- c. A chemical reaction
- d. A physical change

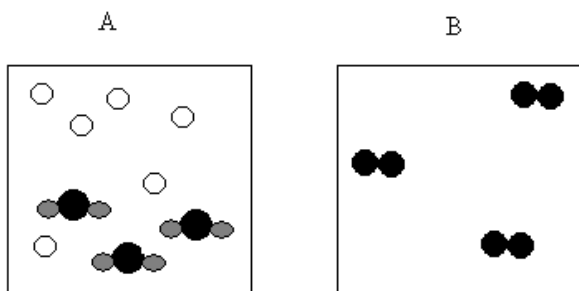
21. Colloidal particles are large enough to be seen under a microscope.

- a. True
- b. False

22. Observations such as density, color, odor, boiling point, and hardness are

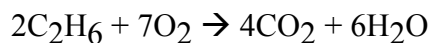
- a. chemical properties
- b. physical properties

Look at the boxes to answer the following question.



23. The sample in box B could be considered a(n)
- Element
 - Compound
 - Mixture

Use the following chemical equation to answer the following questions.



C_2H_6 = ethane

O_2 = oxygen

CO_2 = carbon dioxide

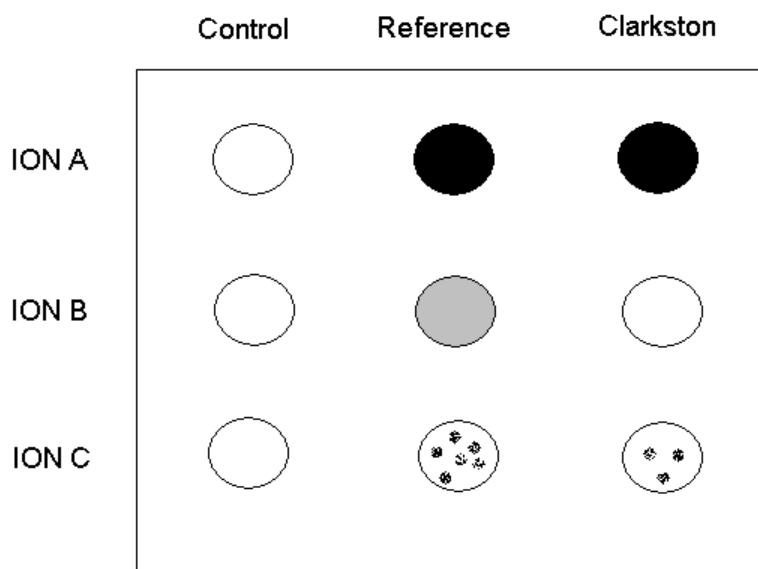
H_2O = water

24. What is the correct way to read this equation?
- 4 carbons and 12 hydrogens plus 14 oxygens give me 4 CO_2 and 6 waters.
 - Ethane and oxygen equal carbon dioxide and water.
 - 2 molecules of ethane react with 7 molecules of oxygen to yield 4 molecules of carbon dioxide and 6 molecules of water.
 - Both a. and c.
25. Carbon dioxide is a
- Product
 - Reactant
26. Which of following is not a symbol for an element?
- Fe
 - N
 - CO
 - Ca
27. If an atom has 14 protons, 15 neutrons, and 16 electrons, what is its charge?
- 0
 - 1
 - 2
 - +2
 - +1
28. If a sample of matter contains different particles, we can definitely call it a(n):
- heterogeneous
 - element
 - compound
 - mixture

29. Substances in a chemical reaction that exist before the reaction takes place are called the
- Reactants
 - Products
 - Protons
 - Electrons
30. Positively charged subatomic particles are called
- Positrons
 - Electrons
 - Protons
 - Neutrons
31. Neutrons have a ____ charge.
- Positive
 - Negative
 - Neutral
32. Which of the following could indicate a positive test in the ion testing lab?
- A color change
 - A precipitate
 - Looking similar to the control
 - Both a. and b.
33. In the ion testing lab, we tested for the presence of four different ions, but we did not determine the actual amount of ion present. What type of test did we conduct/
- A quantitative test
 - A qualitative test
34. In testing water for ions, a reference solution is used to
- Show what happens when the ion is present in the test.
 - Show what happens when the ion is not present in the test.
 - Make sure the unknown sample contains the ion that is being tested.
 - Check to see if the control has ions in it.
35. What is the formula for the compound sodium hydroxide?
- SOH
 - NaOH
 - NaOH₂
 - Na(OH)₂
36. What is the formula for a compound containing aluminum and sulfate ions?
- AlSO
 - AlSO₄
 - Al₃(SO₄)₂
 - Al₂(SO₄)₃

37. If Ca^{2+} ions combine with NO_3^- ions, what would be the formula for this compound?
- CaNO_2
 - CaNO_3
 - $\text{Ca}(\text{NO}_3)_2$
 - Ca_2NO_3
38. An ion with a charge of 3^+ can combine with three other ions if each of these ions has a charge of
- 1^+
 - 1^-
 - 3^+
 - 3^-
39. How many atoms of each element can be found in one particle of $\text{Al}_2(\text{SO}_4)_3$?
- 2 aluminum, 3 sulfur, and 12 oxygen
 - 2 aluminum, 1 sulfur, and 12 oxygen
 - 2 aluminum, 3 sulfur, and 7 oxygen
 - 2 aluminum, 3 sulfur, and 3 oxygen

Look at the following diagram to answer the following questions.



40. What ions are present in Clarkston's water, according to the well plate?
- Ions A and B
 - Ions B and C
 - Ions A and C
 - Ions A, B, and C

APPENDIX B

WATER SECTION CD TEST

1. The solubility of gases _____ with increase of temperature:
 - a. increases
 - b. decreases
 - c. stays the same
2. You have a test tube containing a clear solution. Additional solute is added and it all dissolves. We can assume the original solution was
 - a. unsaturated
 - b. saturated
 - c. supersaturated
3. A solution where more than the maximum amount of solute is dissolved for the given conditions is impossible to make.
 - a. True
 - b. False
4. A solution that cannot dissolve any more solid is said to be:
 - a. unsaturated
 - b. saturated
 - c. supersaturated
 - d. solvent rich
5. In solid lithium bromide, the lithium has a positive charge and the bromide a negative charge. Lithium bromide is water soluble. Which part of the water is responsible for dissolving the "lithium" portion of the lithium bromide?
 - a. whole water molecule carries away the lithium
 - b. the hydrogen portion of the water
 - c. the oxygen portion of the water
6. What is the percent concentration of a solution that contains 56g of LiCl in 120g of water:
 - a. 0.32%
 - b. 2.1%
 - c. 32%
 - d. 47%
7. Determine the percent by mass of NaNO_3 in a solution that contains 32 grams of NaNO_3 in 375 grams of solution?
 - a. 7.8%
 - b. 8.5%
 - c. 10.9%
 - d. 11.7%

8. You are given 100 grams of a 25% sugar solution by mass. This solution contains
- 25 grams of sugar and 75 grams of water
 - 25 grams of sugar and 100 grams of water
 - 75 grams of sugar and 25 grams of water
 - 100 grams of sugar and 25 grams of water
9. A .045 gram sample of ethanol is dissolved in 155 grams of water. What is the concentration of ethanol, expressed in ppm?
- .029 ppm
 - 4.5 ppm
 - 45 ppm
 - 290 ppm
10. Which of the following does not affect solubility?
- temperature
 - polarity of the solute
 - polarity of the solvent
 - all the above affect solubility
11. You test the solubility of a solute in three different solvents: water, vegetable oil, and hexane. What can you determine from the results :
- Water: soluble Vegetable Oil: insoluble Hexane: insoluble
- The solute is polar
 - The solute is nonpolar
 - The solute is both polar and nonpolar
 - There is not enough information to answer the question
12. What is the effect of increased pressure on the solubility of gases?
- no effect
 - an increase in solubility
 - a decrease in solubility
13. Which pH indicates the greatest hydrogen ion concentration?
- 1
 - 5
 - 11
 - 14

For the following questions, identify the water source in each pair that contains the greatest amount of dissolved oxygen.

14. Which has more dissolved oxygen?
- A lake with only catfish
 - lake containing trout

15. Which has more dissolved oxygen?
- A river with rapids
 - quiet lake
16. Ionic compounds can be dissolved by _____.
- nonpolar compounds
 - polar compounds
 - all solvents
 - all solutes
17. A pond is contaminated with a chemical that is a base. Which ion will be present in higher concentration than in uncontaminated water?
- H^+
 - OH^-
 - SO_4^{2-}
 - Ba^{2+}
18. If the pH of pool water is too low, "soda ash" might be added to bring it up. Soda ash must be
- an acidic compound
 - a basic compound
 - a neutral compound
19. If I have a solution containing less than 0.1 grams of solute in a 1000.0 grams of solvent, how should I represent the concentration and why?
- Parts per million, because it will give me a reasonable number
 - Parts per million, because it will be inaccurate if I write the concentration as a percent
 - Percent, because it will give me a reasonable number
 - Percent, because it will be inaccurate if I write the concentration as parts per million
20. Water can dissolve ionic compounds. Which phrase best describes how this happens?
- ionic compounds fit in between water molecules
 - polar water molecules attract the ions in ionic compounds
 - nonpolar bonds are made between water and ionic compounds
 - water is nonpolar while ionic compounds have charges

Refer to the solubility curve to answer the following questions.

21. What mass in grams of KNO_3 will dissolve in 100g of water at 50 °C:
- 38g
 - 41g
 - 71g
 - 81g

22. What is the maximum amount of KNO_3 that can be completely dissolved in 120g of water at 20°C :
- 27g
 - 32g
 - 38g
 - 120g
23. Judging from the graph, which of the solutes has the greatest solubility at 10 degrees:
- KNO_3
 - KCl
 - NaCl
 - All about equal
24. The source of mercury in Michigan fish is primarily
- old paint
 - plumbing
 - thermometers
 - coal burning
25. Changing the formula of gasoline reduced the emissions of which heavy metal
- lead
 - mercury
 - cadmium
 - iron
26. HCl is a(n):
- acid
 - neutral
 - base
 - none of the above
27. Bases have a pH of:
- less than 7
 - more than 7
 - equal to 7
 - less than 5
28. The procedure of water purification where large objects are removed is called:
- aeration
 - screening
 - fluoridation
 - disinfection

29. Some municipalities add a soluble fluoride compound to their drinking water supply to
- eliminate iron ions from the water
 - eliminate the bacteria found in water
 - reduce the need to brush teeth to remove bacteria
 - reduce tooth decay by strengthening tooth enamel.
30. The part of water purification that involves the adding of aluminum sulfate and slaked lime to remove suspended particles from the water via a gel-like substance is known as:
- sand filtration
 - aeration
 - flocculation
 - fluoridation
31. Hard water could be caused by all of the following ions except:
- Ca^{2+}
 - Mg^{2+}
 - Fe^{3+}
 - Cd^{2+}
32. Why is some chlorine left in water after it leaves a water purification plant?
- because it kills microorganisms giving water some protection once it leaves the plant
 - because it is too difficult and expensive to remove
 - has no ill effects on humans so it would be a waste of time to remove
 - improves the taste of water
33. Compared to the rest of the country, Michigan's water is _____ than most areas.
- harder
 - softer
 - normal
34. In municipal (city) drinking water treatment, the function of aeration is to _____ .
- Supersaturate the water with oxygen to prevent large predatory fish from entering the drinking supply
 - make the water flow easier through pipes
 - improve the flavor
 - provide a fun fountain for neighborhood kids to play in
35. What step does the filtering of your drinking water (assuming you are on well) and my municipal drinking water have in common?
- sand filtration
 - evaporation
 - flocculation
 - chlorination

36. Some water softening units use ion exchange resins. Which statement is an example of an exchange that occurs in such a unit?
- Calcium ions are exchanged for magnesium ions.
 - Magnesium ions are exchanged for chloride ions.
 - Calcium ions are exchanged for iron ions.
 - Calcium ions are exchanged for sodium ions.
37. Which substances can be found in a water filter that is either in your refrigerator or attached to your faucet?
- sand
 - activated charcoal
 - ion-exchange resin
 - both b. and c.
38. In most of the fish kill scenarios, what started the chain of events that led to the death of the fish?
- farmers polluting the river
 - higher than normal rainfall
 - too much mining
 - pollution from the fall fish-in
39. The book listed using ozone, ultraviolet light, and charcoal filters as alternatives to chlorination. What is a common disadvantage of all three?
- They are more expensive.
 - They leave a bad taste in the water.
 - They do not protect the water once it leaves the water treatment plant.
 - They are all very toxic and dangerous substances.

Use the table to answer the following questions about the concentrations of ions from Pontiac Lake.

Metal Ion	Concentration in January	Concentration in July	EPA limit humans	Risk Factor
<i>Selenium</i>	.004 ppm	.008 ppm	.01 ppm	.8
<i>Arsenic</i>	.0002 ppm	.0002 ppm	.05 ppm	.004
<i>Lead</i>	.01 ppm	.02 ppm	.05 ppm	.4
<i>Mercury</i>	.0004 ppm	.06 ppm	.05 ppm	1.2

40. Assuming no changes in the population or industrial activity in the area, what would be the primary reason for the increase in concentrations between January and July?
- The volume of the lake is higher in the summer because of the snow and ice melting
 - Dead fish release more of these ions into the water
 - The water is warmer in July
 - All of the above

APPENDIX C

RESOURCE SECTION AB TEST

1. Below is a list of some properties of the element chlorine.
- a yellow gas
 - a gas that will form hydrochloric acid in your lungs
 - denser than air
 - a substance with a boiling point of $-101\text{ }^{\circ}\text{C}$

How many of these properties are physical?

- a. 1
 - b. 2
 - c. 3
 - d. 4
2. The current periodic table is based upon increasing
- a. atomic mass
 - b. neutron number
 - c. atomic number
 - d. activity series
3. Which of these is a chemical property?
- a. resistance to corrosion
 - b. malleability
 - c. boiling point
 - d. solubility in water
4. Which of the following is a physical change?
- a. melting iron
 - b. rusting iron
 - c. converting iron from its ore
 - d. all of the above
5. Which of these observations is evidence of a chemical change?
- a. A drink mix dissolves in water.
 - b. Bubbles of a gas explode when ignited.
 - c. Rubbing alcohol evaporates from a surface.
 - d. A pop can is crushed by a hammer.
6. Which of these elements has chemical properties most like beryllium (Be)?
- a. Lithium
 - b. Strontium
 - c. Boron
 - d. None of the above

7. Elements in the same family have similar chemical properties because they have the same
 - a. activity
 - b. atomic number
 - c. mass number
 - d. number of electrons in their outer shell

8. Which of these elements is most chemically similar to phosphorus?
 - a. Si
 - b. S
 - c. C
 - d. N

9. On the periodic table, nonmetals are mostly found on the
 - a. Top
 - b. Bottom
 - c. Left
 - d. Right

10. Elements that are in the same vertical column on the periodic table are collectively referred to as a
 - a. Group
 - b. Family
 - c. Period
 - d. Both a and b

11. If calcium's melting point is 110°C and barium's melting point is 145°C , what would strontium's melting point most likely be:
 - a. 255°C
 - b. 135°C
 - c. 128°C
 - d. 90°C

12. Which list has elements that are all in the same chemical family?
 - a. Ca, Y, Ba
 - b. Cu, Ag, Au
 - c. Al, Ge, In
 - d. Br, Xe, At
 - e. Sn, Sb, Te

13. Which list has elements that are all in the same period?
 - a. Rb, Sr, La, Zr
 - b. Hg, Tl, Pb, Bi
 - c. Al, Ga, Si, P
 - d. N, O, Cl, Ne
 - e. O, S, Se, Te

14. The boiling point of HCl is $-85\text{ }^{\circ}\text{C}$ while the boiling point of HI is $-36\text{ }^{\circ}\text{C}$. Estimate the boiling point of HBr, in $^{\circ}\text{C}$.
- $-51\text{ }^{\circ}\text{C}$
 - $-41\text{ }^{\circ}\text{C}$
 - $-56\text{ }^{\circ}\text{C}$
 - $-61\text{ }^{\circ}\text{C}$
15. What is the difference between oxygen-15 and oxygen-16?
- Oxygen-15 has 7 neutrons and oxygen-16 has 8 neutrons.
 - Oxygen-15 has 7 protons and oxygen-16 has 8 protons.
 - Oxygen-15 has 15 neutrons and oxygen-16 has 16 neutrons.
 - Oxygen-15 has 15 protons and oxygen-16 has 16 protons.
16. The greatest variety of elemental resources is located in what specific layer of the Earth?
- Core
 - Mantle
 - Crust
 - Hydrosphere
17. A neutral atom of magnesium-23 has
- 12 protons, 12 electrons, and 11 neutrons
 - 12 protons, 11 electrons, and 12 neutrons
 - 11 protons, 12 electrons, and 12 neutrons
 - 23 protons, 23 electrons, and 12 neutrons
18. Which of the following is a property of nonmetals?
- high luster
 - low thermal conductivity
 - ductile
 - malleable

For the following questions, you are given the following known formulas:



Predict the formulas of the following combinations of elements.

19. Na and I
- NaI
 - NaI₂
 - NaI₃
 - Na₂I
20. Al and Cl
- AlCl
 - AlCl₂
 - AlCl₃
 - Al₂Cl₃
21. Be and Br
- BeBr
 - BeBr₂
 - BeBr₃
 - Be₂Br

22. The middle layer of the Earth's lithosphere is the
- crust
 - mantle
 - core
 - hydrosphere
23. Carbon-14 and nitrogen-14 have the same
- atomic number
 - mass number
 - number of protons
 - number of neutrons
24. A metal is usually obtained from its ore by a process called:
- Melting
 - Casting
 - Oxidation
 - Reduction

Metals and solutions were mixed together in a well plate and checked for reactions. The following data table was produced:

	NaNO₃	NbNO₃	Al(NO₃)₃	Ni(NO₃)₂
Na	----- --	Reaction	Reaction	Reaction
Nb	No reaction	----- --	No reaction	No reaction
Al	No reaction	Reaction	----- -	Reaction
Ni	No reaction	Reaction	No reaction	----- --

25. Based on the data, what is the least active metal?
- sodium
 - niobium
 - aluminum
 - nickel
26. Which of the above metals would be most difficult to be extracted from its ore?
- sodium
 - niobium
 - aluminum
 - nickel
27. What happens to the electrons of a metal atom during oxidation?
- Electrons are lost by the atom.
 - Electrons are gained by the atom.
 - The nucleus captures electrons.
 - The nucleus emits electrons.

28. Low grade ores are less desirable than high grade ores because they:

- Are more difficult to mine
- Yield less metal per ton of ore
- Are scarcer than high grade ore
- Cost less per ton of ore

29. In the periodic table, the most active metals are found

- at the far left side
- at the far right side
- directly to the left of the step-like line
- directly to the right of the step-like line

Use the table to answer the following questions.

Element	Malleable / Brittle	Color	Shiny or dull	Conductor	Reacts with Acid?
A	Brittle	Yellow	Dull	No	No
B	Malleable	Silver	Shiny	Yes	Yes
C	Brittle	Grey	Shiny	Yes	No
D	Brittle	Black	Dull	Yes	Yes

30. Which of the following elements could be classified as a metal?

- element A
- element B
- element C
- element D

31. Which of the following elements could be classified as a nonmetal?

- element A
- element B
- element C
- element D

Look at the following table, then use your periodic table to fill in the blanks. Assume the atoms are neutral.

Element	Symbol	Atomic Number	Mass Number	Protons	Neutrons	Electrons
Tungsten	(32)	74	(33)	(34)	110	(35)
Cobalt	Co	(36)	59	(37)	(38)	(39)

32. a. T b. Tu c. W d. Ta

33. a. 36 b. 74 c. 110 d. 184

34. a. 36 b. 74 c. 110 d. 184

35. a. 36 b. 74 c. 110 d. 184

36. a. 27 b. 32 c. 59 d. 86

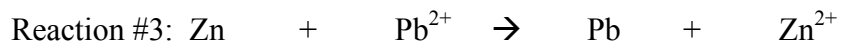
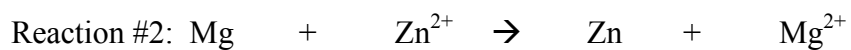
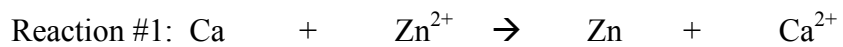
37. a. 27 b. 32 c. 59 d. 86

38. a. 27 b. 32 c. 59 d. 86

39. a. 27 b. 32 c. 59 d. 86

Use the activity series and the redox reactions to answer the following questions.

Activity Series				
Most active	→	→	→	Least active
Calcium	Magnesium	Zinc		Lead



40. Which of these reactions should not work?

- Reaction #1
- Reaction #2
- Reaction #3
- All reactions will work.

APPENDIX D

AIR SECTION AB TEST

1. The area of the atmosphere closest to the earth's surface is called the
 - a. stratosphere
 - b. troposphere
 - c. ozone layer
 - d. thermosphere

2. Which of the following is part of the kinetic molecular theory?
 - a. A gas is composed of very tiny particles.
 - b. The particles of a gas are in continual curvy motion.
 - c. The particles of a gas do lose energy and slow down when they collide.
 - d. The particles of a gas have definite shape and volume.

3. Air is a pure substance.
 - a. True
 - b. False

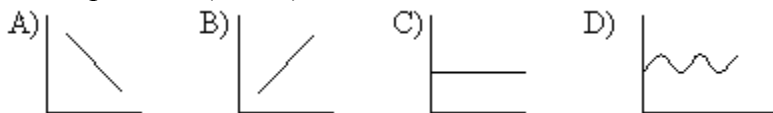
4. Which gas is the most abundant gas in the atmosphere?
 - a. nitrogen
 - b. hydrogen
 - c. oxygen
 - d. argon

5. Air is best described as
 - a. a substance
 - b. a compound
 - c. an element
 - d. a mixture

6. When an inverted glass jar is lowered into a container of water, the water does not enter the jar. This demonstration shows that air
 - a. has mass
 - b. has high solubility in water
 - c. is a mixture of gases
 - d. takes up space

7. Standard atmospheric pressure can be expressed as
 - a. 100 mm Hg
 - b. 100 atmospheres
 - c. 760 mm Hg
 - d. 760 atmospheres

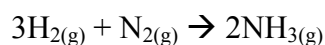
8. Which values represent standard temperature and pressure?
- 0 °C and 1 atm
 - 273 K and 760 kPa
 - 273°C and 760 atm
 - 0 K and 101.3 kPa
9. When the aluminum can was heated and inverted in a pan of water, the can collapsed. This demonstrates that
- air has mass
 - air pressure is inversely proportional to temperature
 - increasing the temperature of a gas increases its kinetic energy.
 - we are subject to relatively high air pressure even though we don't notice it.
10. What causes pressure inside a tire?
- gas molecules colliding with each other
 - gas molecules colliding with the wall of the tire
 - the diffusion of the gases
 - constant changing of temperature
11. Which term best describes the relationship between pressure and volume of a gas?
- inverse
 - direct
 - complimentary
 - indirect
12. Why is mercury preferred over water for use in barometers?
- it is easier to see than water
 - it is less expensive than water
 - the size of the barometer is more manageable
 - it is more toxic to use
13. Which of the following graphs best represents the relationship between pressure (y-axis) and temperature (x-axis)? Assume the volume is held constant.



- A
- B
- C
- D

14. Which temperature is equal to -36°C ?
- 36 K
 - 237 K
 - 273 K
 - 309 K

15. Given the balanced equation:



Which of the following statements is false?

- 3 moles of hydrogen gas react with 1 mole of nitrogen gas to produce 2 moles of ammonia.
 - 3 L of hydrogen gas react with 1 L of nitrogen gas to produce 2 L of ammonia.
 - 3 grams of hydrogen gas react with 1 gram of nitrogen gas to produce 2 grams of ammonia.
 - 3 molecules of hydrogen gas react with 1 molecule of nitrogen gas to produce 2 molecules of ammonia.
16. Which sample of gas has the highest average kinetic energy?
- helium at 0°C
 - carbon dioxide at 20°C
 - hydrogen chloride at 40°C
 - nitrogen at 60°C
17. Pressure can be increased by _____ the force and _____ the area.
- increasing, increasing
 - decreasing, decreasing
 - increasing, decreasing
 - decreasing, increasing
18. When temperature decreases, volume _____ if pressure is kept constant.
- increases
 - decreases
19. When temperature increases, pressure _____ if volume is kept constant.
- increases
 - decreases
20. The majority of the Earth's atmosphere is oxygen.
- True
 - False

21. 25 degrees Celsius is equal to _____ Kelvin.
- 248
 - 0
 - 25
 - 298
22. You have 1.42 L of a gas exerting a pressure of 125 kPa. Assuming constant temperature, what pressure will the gas exert if its volume is reduced to 0.853L?
- 75.1 kPa
 - 208 kPa
 - 151 kPa
 - more information needed
23. You have 30mL of a gas collected at 100K. What volume will it occupy at 300K?
- 10 mL
 - 60 mL
 - 90 mL
 - 120 mL
24. I want to know the temperature of helium in a balloon. The volume of the balloon is 2.5 L. It has a pressure of 0.9 atm and contains 2.3 moles of helium. The temperature is _____
- 1 K
 - 5 K
 - 5.7 K
 - 12 K
25. I have a balloon with a volume of 2.00 liters. If I simultaneously double the pressure on the balloon and double the temperature of the balloon, what is the new volume?
- 0.50 L
 - 2.00 L
 - 4.00 L
 - 8.00 L
26. A gas has a pressure of 801mm Hg at 349 K. If the pressure is reduced to 701 mm Hg, what will be the new temperature? (Assume volume is kept constant)
- 250 K
 - 305 K
 - 399 K
 - 802 K
27. _____ As frequency decreases, wavelength
- increases
 - decreases

28. ____ As frequency decreases, energy
- increases
 - decreases
29. ____ If the Earth had a thinner atmosphere, the daily range of temperatures would be
- greater
 - less
 - the same
30. ____ Which of the following are considered greenhouse gases?
- water
 - carbon dioxide
 - methane
 - all of the above
31. ____ Which of the following is NOT responsible for an increase in the amount of CO₂ in the atmosphere?
- the increased burning of fossil fuels
 - the destruction of the rain forests
 - the depletion of the ozone layer
 - ALL of the above are responsible for an increase in carbon dioxide in the atmosphere.
32. How do you know you've reached absolute zero?
- Gases would theoretically lack volume.
 - Molecules stop moving
 - Both a + b
33. Why in the specific heat lab, the temperature of the metal dropped close to 70 degrees while a similar mass of water only increased about 3 degrees?
- metal had a high specific heat, while water has a low specific heat.
 - metal had a low specific heat, while water has a high specific heat.
 - the Styrofoam cup affected the results.
 - the thermometer was read incorrectly.
34. The shortest, most penetrating, and most powerful wavelengths of those listed below are in the range of
- ultraviolet
 - radio waves
 - infrared
 - visible light
35. Energy from the sun is transmitted to the Earth as
- nucleotides
 - heat
 - electromagnetic radiation
 - thermonuclear radiation

36. In the greenhouse effect, more infrared gets trapped in the atmosphere than enters. How is this possible?
- Not only does infrared radiation come into the atmosphere via the sun, but ozone creates its own infrared radiation
 - Higher energy electromagnetic radiation is re-emitted as lower energy infrared radiation
 - Lower energy electromagnetic radiation from the sun is converted to and re-emitted as
 - higher energy infrared radiation
37. Which of the following forms of electromagnetic radiation has the most energy?
- x-rays
 - visible light
 - radio waves
 - they all travel at the same energy
38. When solar radiation gets trapped in the atmosphere the result is called
- greenhouse effect
 - ozone effect
 - nuclear winter
 - photochemical effect
39. Which of the types of ultraviolet radiation can kill bacteria and viruses (hint: it's the one with the most energy)?
- UV-A
 - UV-B
 - UV-C
 - UV-D
40. If an object has a low specific heat, how does this relate to the amount of heat an object retains?
- The object absorbs less heat as its temperature rises, and gives off less as its temp falls
 - The object absorbs more heat as its temperature rises, and gives off more as its temp falls
 - Doesn't affect the heat flow of an object
41. Which of these phrases best describes wavelength?
- the number of waves that pass a given reference point per second
 - the distance between the same point on two successive waves
 - the rate of oscillation of waves
 - the time necessary for one wave to pass a particular point
42. Which statement is true if a substance has a high specific heat capacity?
- It requires a large amount of energy to increase its temperature.
 - It requires only a small amount of energy to increase its temperature.
 - Its temperature has been increased to the maximum point.
 - It will heat up quickly.

43. The major reflectors of solar radiation on Earth are
- clouds and particles in the atmosphere
 - oceans and lakes
 - forests and grasslands
 - sand, rocks, and concrete
44. Which gas traps infrared radiation in the Earth's atmosphere?
- carbon dioxide
 - oxygen gas
 - helium
 - argon
45. Where is the largest amount of Earth's carbon located?
- in human cells and bones
 - in CO₂ dissolved in the oceans
 - in fossils and carbonate rocks
 - in living animals and plants
46. The color of an object is determined by the frequencies of the light (radiation) it reflects.
- True
 - False
47. Since the atmosphere of the planet, Venus, is 96% carbon dioxide, the average surface temperature of Venus is
- less than the average surface temperature of Earth
 - greater than the average surface temperature of Earth
 - the same as the average surface temperature of Earth
48. The reaction for respiration is the reverse reaction for the process of
- refining iron ore
 - combustion
 - precipitation
 - photosynthesis
49. A stainless steel grill grate weighing 700 grams with a specific heat of 0.51 J/g•°C was heated by the fire from the grill. The temperature of the grates before ignition was 25 degrees Celsius and before the fire was extinguished it had a temperature of 350 degrees. How much energy was absorbed by the grates?
- 1.10 J
 - 116,000 J
 - 125,000 J
 - 446,000 J

Use the following laboratory data to answer the next question

Volume of water in calorimeter	75.0 ml
Mass of metal	45.2 g
Specific heat of water	4.18 J/g*°C
Temperature of water on hot plate	98.0 °C
Initial temperature of water in calorimeter	21.0 °C
Final temperature of water in calorimeter	25.0 °C

50. What is the specific heat of the metal?

- a. 0.38 J/g*°C
- b. 4.18 J/g*°C
- c. 6.90 J/g*°C
- d. 1254 J/g*°C

APPENDIX E

ENVIRONMENTAL CHEMISTRY POWERPOINT GAME PROJECT

Purpose: For the first half of the Resource Unit (Parts A and B), you will be designing a game for other students to play. The purpose is not to learn by playing the game (although the games can be played for review), but rather to learn by actually constructing the game. You will be using *Microsoft PowerPoint* as your game design software.

The game consists of three parts: a narrative, rules, and questions. You will be developing these over the course of the unit. We will also spend several days in the computer lab, although most of your work will be done outside of the computer lab. Those days are for assembling the games.

The game should be designed under the following premise: *You are tasked to design a game for 9th graders to teach them about the mining of metals from the earth. The premise of the game is that you are the CEO of a mining company given a contract to design a new coin for the U.S. Mint. You must cover the objectives in Part A and Part B of the Resource Unit.*

A rubric will be provided for how the games will be scored. Here are some things to do if you want a **LOW** score on this project:

- Write only very simple, fact-based questions
- Have questions in a random order
- Have a narrative that is completely detached from the content (e.g., “Save the princess...” or “Jeopardy!®”)
- Do not turn in drafts on due dates
- Write questions not based on objectives for Part A and B

You will be working in groups of two. Each person is responsible for 10 questions; therefore, your game should have 20 questions. Questions must have corrective feedback.

- No more than 10 of the questions should be “Knowledge” questions.
- No fewer than 5 questions should be “Comprehension” questions.
- No fewer than 5 questions should be “Application” questions.

Lab Dates (subject to change)

Due Dates

Narrative: _____

Part A Questions: _____

Part B Questions: _____

Group Members: _____

Hour: _____

Title of Game: _____

Category	Poor (0)	Good (1)	Excellent (2)		Total
Content	Many questions are incorrect	Some questions are incorrect	Questions are correct	X2	
	No higher order questions are written	Too many questions are too simple	Questions vary in difficulty	X2	
	Many of the objectives were not covered in the game	A few objectives were not covered in the game	All of the objectives were covered in the game.	X2	
	No feedback given for incorrect answers	Some feedback given for incorrect answers.	Feedback given for incorrect answers is frequent and useful	X2	
Organization	There is no organization to the questions		Questions increase in difficulty as the game progresses	X1	
Style	Many questions are poorly worded; some make no sense whatsoever	Some questions are poorly worded	Questions are well worded	X2	
	The narrative is nonexistent or inappropriate	The narrative is interesting, but the game/questions do not relate to it at all	The narrative, game, and questions are intertwined	X2	
Technology Skills	Game has many errors which affect playability	Game has a few minor errors	Game has no technical errors	X1	
	Required slides (copyright, objectives, etc.) were not completed		Required slides completed	X1	
				Total	

APPENDIX F

GAME PROJECT NARRATIVE ORGANIZER

Narrative or Story Pattern	Prompt Questions	Your Narrative Elements
Characters: the characteristics of the main characters in the story	Who are the main characters? What distinguishes them from other characters?	
Setting: The time, place, and context in which the story took place	When and where did the story take place? What were the circumstances?	
Initiating event: the impetus that starts the action rolling in the story.	What prompted the action?	
Internal response: how the main characters react to the initiating event and plan to respond	How did characters plan a course of action?	
Goal: what the main characters decide to do as a reaction to the initiating event (sometimes this is the goal they set).	What did the main characters decide to do? Did they set a goal? What was it?	
Consequence: how the main characters try to accomplish the goal.	How did the main characters try to accomplish their goals?	
Resolution: how the goal turns out.	What were the consequences?	

Narrative Story Elements Graphic Organizer	
Main Characters	Setting
↓	↓
Problem / Goal	
↓	
Beginning	
↓	
Middle	
↓	
End	
↓	
Lesson Learned / Theme	

APPENDIX G

Gaming Impact or Just Students Themselves? Factors Predicting Student Success in Chemistry

Games are changing the way we look at work and learning (Squire, 2006). Games are creating a culture of being and doing through designed experiences. Yet, there are still negative connotations around educational gaming because they are usually associated with leisure, violence, and a distraction to the learning process in general (Ferguson, 2010; Rice, 2006). However, games provide learners with opportunities to solve problem and collaborate (Kafai, 2006), providing experiences that hone the skills students need in the twenty-first century (Kebritchi & Hirumi, 2008).

One approach to learning chemistry is to have students play educational games (Deavor, 2001; Keck, 2000; Nowosielski, 2007). However, an alternative approach involves having students design the games themselves. The rationale behind this approach is constructionism, which is the idea that students learn by building artifacts (Papert, 1991). Kafai (2006) stated that students learn content knowledge and technical fluency through the decision process of designing games, and that games used in an instructivist manner simply *sweetened* learning. Unfortunately, one drawback of game design is the time involved with teaching and learning the programming language often required (Rice, 2006). Content specific courses, particularly at the secondary level, may not have the time available to cover all of the required objectives and basic programming skills. This has led researchers to examine the application of the concepts of game design utilizing more common computer programs.

Until recently, research involving homemade PowerPoint games resulted in no statistically significant differences (Barbour, Clesson et al., 2011; Barbour, Kinsella et al., 2011; Parker, 2004; Siko et al., 2011). However, Siko et al. (2011) questioned whether using the

homemade PowerPoint games for review – as each of these studies had implemented the game – actually constituted Papert’s (1991) view of constructionism because students were reviewing content already learned, as opposed to constructing new knowledge. Further research into the use of homemade PowerPoint games has focused on the actual pedagogy used when implementing the games in the classroom.

One of the difficulties in educational research is the fact that field studies are often messy (Bogdan & Biklen, 2007). There are many factors influencing student performance on assessments in schools. For example, there have been many studies examining factors that predict performance in chemistry, such as gender, age, chemistry and mathematics background, and GPA (Andrews & Andrews, 1979; Chandran, Treagust, & Tobin, 1987; Simpkins, Davis-Kean, & Eccles, 2006; Tai, Ward, & Sadler, 2006). The purpose of this analysis is to examine which factors affect student performance on a chemistry test. In this article I will review the literature concerning the use of homemade PowerPoint games, as well as literature involving factors predicting success in chemistry. Then, I will discuss how I conducted an experiment using the data from Siko et al. (2011). Next, I will analyze the test data – along with other indicators of student achievement – to examine which factors best predict chemistry achievement of the students, and whether the use of homemade PowerPoint games is a factor. Finally, I will discuss the implications and directions for analyzing data in future studies involving homemade PowerPoint games.

Literature Review

Research with homemade PowerPoint games began at the University of Georgia (Rieber, n.d.). Students design games from a PowerPoint template where they provide a narrative, set rules for the game, and write questions to provide challenge in the game (Parker, 2004). While

Microsoft PowerPoint is clearly not game design software, it is ubiquitous in schools and therefore can be used in most schools without having to deal with the expense of new software and training for teachers.

Homemade PowerPoint games can be created from a template or by starting with a blank presentation (n.b., the games in this study were created from a template that can be downloaded from <http://it.coe.uga.edu/wwild/pptgames>). The games can require external elements (e.g., dice, game board) or the game can be completely contained within the *MS PowerPoint* file. Students create a game narrative, which is limited to a single slide in the file. Students also create an objective slide, which tells the player how to play the game and how the game is won. Most of the games consist of players answering multiple-choice questions correctly in order to progress successfully through the game, meeting the goal stated in the narrative.

Philosophical Justification for Using Homemade PowerPoint Games

The justification for using homemade PowerPoint games is three-fold (Barbour, Thomas, Rauscher, & Rieber, 2008). First, the idea of student-designed games is constructionist in nature. The game itself qualifies as the knowledge structure discussed by Papert (1991), and is a meaningful artifact that is student-generated (Kafai & Resnick, 1996). Kafai, Ching, and Marshall (1997) also discussed the importance of representing knowledge in new media. Students also learn by making mistakes, which requires the student to utilize problem-solving skills in order to “debug” the game (Rieber, 2004). The students are forced to break down complex problems into workable parts and alter existing schema about how things should work (Papert, 1980). Papert also noted the motivational aspects surrounding making mistakes without public humiliation, something he believed deterred risk-taking in a traditional classroom setting.

Second, students must create a theme, narrative, and directions – all of which must fit on a single *MS PowerPoint* slide. In order to fit on a single slide, these items must be continually revised and condensed, a process that forces students to state ideas as concisely as possible (i.e., within a defined word limit). One way this concise writing has been used is as a microtheme (Stewart, Myers, & Culley, 2010). Past studies have shown that students who were able to write well in this style (i.e., scored high on microtheme assignments) performed better on other course assessments (Ambron, 1987; Collins, 2000; Kirkpatrick, 1984). Also, writing a narrative provides a creative element to content areas outside of language arts. For example, Jang (2009) used fiction writing rooted in real-life examples in a seventh-grade science class as a motivational tool. Using qualitative methods, the author found that the strategy increased motivation, problem-solving skills, and creativity. Finally, in a meta-analysis of 48 writing-across-the-curriculum studies, Bangert-Drowns, Hurley, and Wilkinson (2004) found that these strategies had a small but positive influence on achievement.

Third, student learning should be influenced when they are given the opportunity to write questions based on the content. In a review of 27 studies using self-questioning techniques, Wong (1985) found that students who were able to write higher-order questions (i.e., higher levels of Bloom's Taxonomy) developed a greater understanding of the material, and even more positive results when the technique was accompanied by higher levels of direct instruction on how to write questions and goals of writing more higher-order questions. Also, Rickards and DiVesta (1974) found that continued practice with question writing led to better understanding of the material. In their review of the literature on question writing, Rosenshine, Meister, and Chapman (1996) found reading comprehension generally increased when question writing was used as a comprehension strategy. Further, Lotherington and Ronda (2010) found students wrote

better questions over time when given the opportunity to not only revise their questions, but to help edit the questions of other classmates as well. To make the game interesting to players, the difficulty of the questions should progress from easy to hard. Thus, students need to create questions that vary in difficulty, decide on a correct answer, develop plausible alternatives, and finally organize the questions in a logical progression of difficulty; all of which force the students to repeatedly analyze the content.

To ensure the game is interesting to students, the designers must somehow link the content or how one progresses through the game to the game narrative. Kafai, Franke, Shih, and Franke (1998) examined game design processes for teaching fractions with both young students and pre-service teachers. The fifth-grade students were tasked with creating games about fractions to be played by younger children. The qualitative analysis of the games yielded several themes. As the students were given structure to their assignment (i.e., asking students to refine their games without asking a specific question about fractions), the students moved from creating games where the questions were extrinsic to the theme (e.g., similar to the television game show *Jeopardy*) to more intrinsic and constructivist games (e.g., cut a pizza and then describe how much is left in fraction form). The games also shifted from a more punitive style to a more evaluative form of feedback (e.g., instead of simply stating that the player's choice was incorrect, the designers built in corrective feedback which stated why the player's choice was incorrect). The authors concluded the game design iteration process allowed for students and teachers to think and reflect on both the teaching and learning of the content.

Research into the Effectiveness Homemade PowerPoint Games

Research on students using homemade PowerPoint games has not shown statistically significant differences in student performance between control and treatment groups. Parker

(2004) used homemade PowerPoint games to teach grammar to middle school students. Students who created games increased their scores between the pre-test and post-test, but the control group still showed greater gains. However, Parker also noted that the control group, who normally outperformed the treatment group, actually scored lower on the pre-test. In other words, their gains appeared greater than the group who created the games. While the comparisons would indicate that the games may not be an effective tool, Parker stated the students in the treatment group scored higher on the post-test than their class average would have predicted. The treatment group as a whole had a near failing grade yet achieved a passing grade on the post-test. Thus, Parker speculated the games served as a motivator for the students.

Further, Barbour, Clesson et al. (2011) conducted a study in a British Literature class comparing the performance of students who created games as a part of a review activity versus those who reviewed using one of several traditional review options. The study showed no statistically significant difference in performance between the groups. The authors noted the small sample size (i.e., 15 students in the control group and 20 in the treatment group) as a possible reason for their findings. Barbour, Kinsella et al. (2011) conducted a similar study in a U.S. History course taught in a blended (i.e., instruction occurred in a face-to-face setting, but also made use of a course management system to deliver content). Similar to Barbour, Clesson et al. (2011) the researchers found no statistically significant difference in student performance; although the students who created the games did perform slightly better than the control group.

Since one of the justifications for the games is the idea that students would write higher-order questions, Barbour, Kromei, McLaren, Toker, Mani, and Wilson (2009) examined the data from the Barbour, Kinsella et al. (2011) study to see if students were indeed writing higher-order questions. They analyzed over 1,900 student questions, and the vast majority of them (i.e., 94%)

were determined to be “Knowledge” level. None of the questions were above the “Application” level on Bloom’s taxonomy. The researchers suggested this lack of higher-order questions could be the reason for the no statistical difference findings.

The largest study involving homemade PowerPoint games to date involved approximately 150 students enrolled in an Environmental Chemistry course (Siko et al., 2011). Student performance was compared on two separate unit tests. Once again, students showed no statistically significant difference in performance. Furthermore, students were compared to see if those who created games twice performed better than those who only created games once, or not at all. While the group who created games twice did perform better than the other populations, it was not statistically significant. An ongoing study examining higher-order question writing (Siko, 2011) has found that students were indeed writing more higher-order questions than in the Barbour et al. (2009) study. However, the end result (i.e., no statistically significant difference) was the same.

Factors Affecting Student Performance in Chemistry

Continued research into the use of homemade PowerPoint games in science should also focus on other potential factors that could lead to differences in performance, as many factors can determine success in a science course. Simpkins et al. (2006) conducted a longitudinal study looking at the long-term effects of participation in math and science activities in elementary school had on 227 students in three Michigan school districts as they progressed from elementary to high school. The researchers found high extra-curricular participation in math and science at the elementary level led to a higher selection of math and science courses at the secondary school level. Beliefs in importance and self-concept were also measured, and the author noted the ability to excel in the earlier grades led to higher expectancies in math and science later in a

student's academic career. Simpkins et al. also noted the cycle involving early participation led to early success, which then led to selecting – and succeeding in – science courses later on. At the secondary level, Chandran et al. (1987) found eleventh grade students' formal reasoning and prior knowledge were related to achievement levels in chemistry, while factors such as memory capacity and field dependence were not.

Several studies have looked at predictors of success in college chemistry, with the goal of finding best practices for secondary chemistry instruction. Among the factors studied include math performance (as indicated by both high school math grades and Scholastic Aptitude Test [SAT] scores), chemistry grades, and enrollment in Advanced Placement (AP) courses. Tai et al. (2006) surveyed over 3500 students enrolled in introductory undergraduate chemistry courses and correlated the results with their final grade in the course. The authors found significant contributions to a regression model from math SAT scores, year when introductory chemistry was taken, calculus grade, AP enrollment, and the students' last math and science grade. The authors also surveyed time spent on various chemistry topics. They found a significant correlation between the time spent on stoichiometry in their high school class and student performance in introductory chemistry. Their model suggested a student who took a high school chemistry course with a rigorous curriculum in stoichiometry would earn a half letter grade higher than peers whose chemistry curriculum did not spend as much time on the topic. Stoichiometry is one of the most math intensive topics taught in chemistry. The authors were also surprised by a strong correlation between calculus enrollment and college chemistry grade, despite the fact that an introductory chemistry course usually has no content requiring calculus. They hypothesized if students have had calculus, they have superior algebra skills and require little to no help on the advanced math that is in the chemistry course.

Andrews and Andrews (1979) also conducted a study examining chemistry grades, high school grade point average (GPA), math SAT scores and their relationship to first year chemistry scores. Using multivariate linear regression, they found that math SAT scores correlated highly with their first-year chemistry score. However, they also saw changes in predictive ability when comparing various levels of SAT scores. For example, they found high SAT scores were not as strongly correlated with high grades as much as low math SAT scores were with lower chemistry grades. Barthel (2001) conducted a similar study, examining the relationships between a second semester chemistry course with first semester grades, math American College Testing (ACT) scores, math grades, composite ACT scores and Piagetian development (as measured by the Test of Logical Thinking instrument). While no predictor was determined to be significantly stronger than all of the others, the math based predictors and the prior chemistry grades (which were presented under the vein of “prior knowledge”) were determined to be the best overall predictors of performance in the second chemistry course.

In summary, proponents believe that having students create homemade PowerPoint games will lead to increased learning due to the use of constructionist pedagogy, writing in the content area strategies, and student-generated questions. However, research findings on the use of homemade PowerPoint games to date have generally found no significant differences in student performance. Current research using the games has focused on their influence on performance in a chemistry course. Several studies involving factors influencing chemistry achievement have linked math and formal reasoning ability, as well as prior knowledge, to success in a chemistry course. These factors became the theoretical basis for this study.

Methodology

The data for this analysis comes from the first trimester of six sections of an environmental chemistry course taught in a large suburban Midwestern high school during the 2010-11 school year. Three sections were taught by one teacher who used the gaming protocol to review for the test, while the other three sections were taught by another teacher who did a traditional review study guide the day before the test. The primary topic of the unit was natural resources, and the material centered on the different types of resources (i.e., renewable and nonrenewable), mining practices, oxidation and reduction reactions, and percent composition of metallic ores. The instrument used in the study was a multiple-choice test that consisted of 40 questions; the same instrument that was used and validated in the Siko et al. (2011) study. Based on the research conducted with homemade PowerPoint games, and the relationships between prior knowledge, previous mathematics and chemistry achievement, we set out to answer the following research questions:

1. Do students who created homemade PowerPoint games perform better on a multiple-choice test than students who completed a traditional review guide?
2. If there is no statistically significant difference between the groups, what factors best predicted achievement on the multiple-choice test?

To answer the first question, an independent *t*-test compared the means of the treatment and control groups to determine if there was a statistically significant difference between the two groups. To answer the second question, a multiple regression model was generated to see which variables best predicted the score on the test. This statistical technique was chosen because we were looking to analyze the relationship between a single dependent variable (i.e., test score) and multiple independent variables (Hair, Black, Babin, Anderson, & Tatham, 2006). If the test

scores were not statistically different, then it becomes important to see what other factors were important in explaining a student's test score. The variables chosen for the analysis were based on prior studies involving factors influencing chemistry achievement (see Table 1).

Table 1

Summary of data collected for multiple regression analysis.

Variable	Dependence	Variable Type	
Test Score	Dependent	Metric	Interval
Overall GPA (X_1)	Independent	Metric	Interval
Algebra I GPA (X_2)	Independent	Metric	Interval
Biology GPA (X_3)	Independent	Metric	Interval
Performance on first test of trimester (X_4)	Independent	Metric	Interval
Performance on second test of trimester (X_5)	Independent	Metric	Interval

The test score was the student's raw score on the instrument. The student's overall GPA was based on their transcript from ninth grade through the first trimester of the 2010-11 school year. The biology GPA and algebra GPA were their average grades for all of the trimesters they were enrolled in those courses. In the case of the former, it was usually two trimester grades averaged together. In the case of the latter, there are several routes to meeting the Algebra I requirement, usually consisting of two or three trimesters. These grades were collected because both courses are prerequisites for the environmental chemistry class and also fall under the category of prior knowledge mentioned in the Barthel (2001) study. The test used in this analysis was the third test given in the course. The last two variables are the raw scores of the first two tests given in the course, another indicator of prior achievement.

The data set consisted of 139 cases. Of these cases, 15 (approximately 10%) of the cases contained missing data. As suggested by Hair et al. (2006), if 10% or fewer of the cases contain missing data, they could be eliminated without further analysis. Therefore, 124 cases were used

for the study, 54 for the control and 70 for the treatment. The ratio of sample size (124) to predictors (5) was also satisfactory based on the suggested guidelines.

Results

The first research question examined whether there were differences in student performance between the control and treatment groups on the unit test (see Table 2).

Table 2

Comparison of Test Scores Between Control and Treatment Groups for the First Unit

Group	<i>N</i>	<i>M</i>	<i>SD</i>
Control	54	30.07	5.12
Treatment	70	28.36	5.64

The group who did a traditional review in preparation for the test performed better than the group who created the games. However, the difference was not determined to be significant, $t(122) = 1.75; p = .083$.

Since the results of the t-test showed no significant difference between the two groups, the regression analysis was performed. The standardized regression equation was found to be: $Y = .256Z_{X1} + .053Z_{X2} + .053Z_{X3} + .274Z_{X4} + .242Z_{X5}$. The adjusted R^2 value was equal to .53, which was determined to be significant ($p < .01$). Of the factors listed, the scores on the first two tests given in the course (X_5 and X_6), as well as overall GPA (X_1) were the most influential factors in predicting the test score ($p < .05$). Algebra I GPA had a zero-order correlation with the dependent variable under 0.5, which according to Hair et al. (2006) made it a suspect variable to include in the regression equation. None of the factors had a tolerance less than 0.1, which is a satisfactory indicator for multicollinearity (i.e., the independent variables are not highly correlated with one another, which can skew the results of a regression). With respect to

outliers, none of the cases in the model had unusual leverage numbers, which would indicate that the case had the ability to significantly skew the results due to its extreme nature (Hair et al., 2006). No case had a leverage value greater than 0.12 or a Cook's distance over 1.0. One case had a Mahalanobis distance slightly over 15, but did not exceed the other measures of outliers.

Discussion

The student performance on the test showed the control group actually performed slightly better than the treatment group, although it was not statistically significant. This result was also found on the first test in the Siko et al. (2011) study – that is the same testing instrument used with the sample in this study. To date there have been statistically insignificant findings in one middle school English test (Parker, 2004), one secondary English test (Barbour, Clesson et al., 2011), two secondary social studies tests (Barbour, Kinsella et al., 2011), and three secondary science tests (the two tests in Siko et al. [2011] and the test in this study).

With respect to the regression model, the students' scores on the previous two tests and overall GPA were statistically significant predictors of the score on the test. However, unlike the studies involving math competency (Barthel, 2001; Tai et al., 2006), algebra proficiency did not play a significant role in the prediction. While it was close to the generally accepted cutoff for significance ($p = .052$), its low zero-order correlation is cause for concern. Furthermore, based on the Andrews and Andrews (1979) study, math should have been a stronger predictor. Their study indicated a stronger correlation between low math SAT scores and low chemistry achievement than at the higher performing end. Students enrolled in the Environmental Chemistry course often selected the course (or were forced into the course) because they do not meet the math requirements for the General Chemistry course offered at this high school.

Despite the studies comparing chemistry and math achievement, one could call into question the definitions of “prior knowledge” and math achievement as it relates to the content tested in this study. In reviewing the content tested in the experiment, there was not a strong emphasis on math calculations. Tai et al. (2006) noted the strongest comparison between prior knowledge and college chemistry performance was with the concepts of stoichiometry, which is arguably more of a mathematics concept than a chemistry concept. About 10% of the questions on the instrument involved calculations, and some of them required nothing more than simple addition and subtraction. In addition, Tai et al. posited that calculus was a strong indicator despite not being used in introductory chemistry due to the possibility of calculus enrollment indicated a very strong algebra student who needed less scaffolding. Although we looked at Algebra I grades, which were common to all of the cases, the students could be enrolled in additional math courses (e.g., Geometry and Algebra II), either before taking Environmental Chemistry or taking it concurrently. Perhaps the student’s grade in Algebra I was not indicative of their current math ability.

The finding that showed the prior two test scores in the course were significant predictors of the score on the test analyzed in this study was consistent with the Barthel (2001) findings concerning the role of prior knowledge in chemistry. While the Chandran et al. (1987) study showed the relationship between formal reasoning and chemistry achievement, one of the difficulties mentioned in the Siko et al. (2011) study was how well a multiple-choice instrument truly measures reasoning skills. Finally, while biology was also a prerequisite course for the class, very few, if any, questions contained any biology content; however, some basic chemistry is taught in biology, and the topics covered in biology (e.g., atoms, subatomic particles, ions) were indeed covered in this unit.

The final significant predictor, overall GPA, is difficult to analyze. On one hand, the finding is different than the findings in the Andrews and Andrews (1979) study (i.e., overall GPA was such a weak indicator that it was dropped from the final analysis). It was, however, not as strong of a predictor as the previous test scores. On the other hand, the variability in rigor of courses that students select could discredit its use as an indicator of overall academic achievement. In other words, a stronger student who takes more difficult classes may have a lower GPA than a weaker student who takes easier classes.

In general, the ability to draw conclusions on the effectiveness of the games was limited due to the fact that the differences in test scores were not statistically significant. With respect to predictors of test scores, prior test scores and overall GPA were found to be statistically significant predictors of the score on the instrument used in the study. Taken together, we may have an issue similar to the Parker (2004) study, where the control and treatment groups did not have a similar makeup. Because of the quasi-experimental design of the game research (i.e., not complete random selection into control and treatment groups), it is possible that some other factors, such as general scholastic ability, played a larger role in predicting student performance on the test.

Conclusion

In this study we examined the effectiveness of game design as an instructional strategy in a secondary chemistry course. Upon finding that student creation of a homemade PowerPoint game did not have a statistically significant effect on student performance, we explored other potential factors that could predict the student outcome on that chemistry test. In addition to the treatment of creating a game as an alternative to a traditional review guide, we considered the possible effects of mathematics and prior science GPA, as well as the current performance in the

class (as measured by student performance on the two previous tests). Using multiple regression, we determined that student performance on the previous tests were the statistically significant contributors to predicting the score on the testing instrument. This was consistent with previous research that found prior knowledge was a predictor of success in chemistry, although it was at odds with research indicating that mathematics knowledge should have also been a predictor.

Practitioners wishing to implement a game design project using homemade PowerPoint games should consider several things. First, given the preponderance of no significant difference findings, time may be a factor when deciding whether to use the games as an instructional tool. If the games are as good as traditional methods of instruction and take longer to complete, there is no practical significance to their use unless one considers them a motivational tool. Second, despite no difference in results, the instructor in the study noted having an easier time with the implementation when more structure was added. He also found the students being more on-task with fewer days in the lab than the Siko et al. (2011) study, where students spent four consecutive days in the computer lab preceding the test.

Further research will continue to look at the data from this study, including an analysis of the questions written by the students for the games themselves to examine the assumption that students are writing higher order questions. Alterations to the methods by which the game design project is executed, such as providing a more structured assignment, changing how the project is framed within the unit, and altering the amount of classroom and computer lab time will also be examined.

Finally, obtaining quality data from educational research can be difficult due to the fact that experiments are often not randomized. Educators know that changes in performance can vary due a particular makeup of a class, which can result from scheduling conflicts and hidden

tracking mechanisms. To better generalize results from a study, methods could be employed to “even the playing field” when it comes to comparing the results of different groups. Further research could take into account a student’s previous academic record. Therefore, we would not only whether examine differences in the performance of the treatment and control groups, but also at the effects on individual student performance of those in the treatment group (similar to Parker’s [2004] analysis). In other words, does the creation of a homemade PowerPoint game improve individual test scores based on previous performance in the course? For practitioners, this could be used as a method to differentiate instruction.

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APPENDIX H

Are They Climbing the Pyramid? Rating Student-Generated Questions in a Game Design Project

Constructionism, an extension of constructivism, is the philosophical orientation that students learn by building artifacts (Papert, 1991). One artifact that students can create is a computer game. Conventional wisdom would dictate that the students would learn by playing educational games; however, research on learning through this process has been underwhelming (Hays, 2010). Constructionists believe that when students create games, the learning would occur during the design and construction of the game more so than the actual playing of the completed artifact.

Designing games can be a difficult endeavor, and designing educational games has the added layer of including educational objectives in the design (Hirumiet al., 2010). Good games should have an enticing storyline, and keep the player motivated by providing the appropriate amount of difficulty (Rieber, Barbour, Thomas, & Rauscher, 2008). Adding to the complexity of using game design as an instructional tool is the programming software itself. Teachers are faced with not only teaching content but teaching computer science as well (Barbouret al., 2010). However, there are several “low-tech” ways to have students design games using more common computer applications such as *Microsoft PowerPoint*. One line of inquiry into low-tech game design is homemade PowerPoint games from a template.

Researchers using homemade PowerPoint games have listed three philosophical justifications for their use: constructionist pedagogy, writing across the curriculum, and student-generated questioning strategies (Barbour, Rieber et al., 2009). However, the use of homemade PowerPoint games has not been shown to increase performance on assessments when compared to groups who do not create games (Barbour, Clesson et al., 2011; Barbour, Kinsella et al., 2011;

Parker, 2004; Siko et al., 2011). This fact has led researchers to examine these justifications in greater detail. In particular, researchers have questioned whether the construction of games does indeed make students write more higher-order questions (Barbour, Kromrei et al., 2009).

In this paper, I introduce homemade PowerPoint games, followed by a review of the literature supporting the philosophical justifications for their use. After reviewing studies involving homemade PowerPoint games, I will detail the results of my question analysis from a recent study involving the use of these games to teach chemistry. Finally, I will discuss potential for future research and provide recommendations for practitioners who wish to use the games as an instructional tool.

Literature Review

A homemade PowerPoint game can be any game created with *MS PowerPoint*. However, templates that can help students by providing structure to their games can be found at <http://it.coe.uga.edu/wwild/pptgames/PPTgame-template1.ppt> (all of the studies reviewed in this paper have used this template). If the students use the template, the game begins with an introductory slide that directs players to information about the game and to the starting point for the game. Students generate a narrative slide, which provides the story behind the game. Students also generate slides which tell players how to play the game and how the game ends (i.e., how a player wins the game). The game itself is usually played by answering a series of multiple choice questions related to some content. All of these slides are linked to this introductory slide.

There are three justifications for using homemade PowerPoint games as an instructional tool. First, the design of games is consistent with constructionist pedagogy. Programming

languages such as *Logo*, *Alice*, and *Scratch* have been used by teachers to teach computer science and other subject areas through the designing of games with much success in improving student performance (Kafai et al., 1997; Peppler & Kafai, 2007). One way that this learning occurs is through trial and error. Papert (1980) believed that students in a traditional classroom were conditioned to avoid failure, whereas a constructionist environment allows for students to make errors without judgment. The second justification for the use of homemade PowerPoint games is the use of narratives in the design of the game. Many games have a short, concise storyline that provides background as to why one is playing the game. While Bangert-Drowns, Hurley, and Wilkinson (2004) only found a small, positive impact in their meta-analysis of 48 writing across the curriculum studies, they did find enhanced effects when the length of the assignment was shortened; such as the writing found in microthemes (Ambron, 1987). Garner (1994) found that grades and motivation increased with the use of microthemes, and student surveys showed a high approval rating for the technique. The final justification is the students' task of writing their own multiple-choice questions for the game. It is this third justification that I would like to examine in greater detail.

As any teacher can attest, writing good questions is not an easy task. The same can be said for students constructing their own questions. Not only does the student have to create a question and come up with the right answer, they must also create several plausible yet incorrect alternatives to distract the player (Rieber et al., 2008). Therefore, the student must work with the content in constructing questions, and even address misconceptions as they develop correct and incorrect choices (Chin & Osborne, 2008). Based on the review of 27 studies examining self-questioning techniques, Wong (1985) gave three justifications for using self-generated questions in the classroom. First, creating questions helped to guide students' thinking as a form of active

processing of content. Second, self-questioning was a metacognitive process which helps students gauge their own understanding. Finally, self-generated questions were supported by schema theory, since the formation of questions help to integrate new information with current schema. Wong's analysis of studies which used self-questioning as an instructional strategy found that the strategy did enhance learning, but only slightly. Examining the studies more closely, Wong determined that the effects were greatest when there was an emphasis on writing more higher-order questions, a longer processing time, and a higher amount of direct instruction on how to write questions. Further, Rosenshine, Meister, and Chapman (1996) conducted a similar study a decade later and, based on their review of 26 studies, found that reading comprehension generally increased when question writing was employed as an instructional technique.

More recently, Lotherington and Ronda (2010) found that fourth-grade students, when creating online board games for a geography course, wrote better questions over time. The researchers also found that allowing the students to revise questions and critique the questions of others were important factors in the development of their question writing skills. Within the science discipline, Harper, Etkina, and Lin (2003) examined the benefits of the technique in an introductory physics course. The researchers found no correlation between the number of questions written by students and their test scores, but did find a significant relationship between the quality of the questions written and test scores. Finally, a review of student-generated questioning studies in science by Chin and Osborne (2008) stressed the importance of scaffolding, prompts, and modeling in determining the success of the technique.

As the bulk of the work in creating a homemade PowerPoint game consists of writing questions, and student-generated questioning is a generally effective strategy, it would appear

that studies involving homemade PowerPoint games would be an effective tool to increase learning. However, all of the published research to date on homemade PowerPoint games has shown no significant difference in performance between control and treatment groups. For example, Parker (2004) examined the use of homemade PowerPoint games to teach grammar skills to middle school students, and found no statistical difference between the treatment and control groups. Similarly, Barbour, Clesson, and Adams (2011) conducted a study in a British literature class involving the use of the games and found no statistical difference in performance between students who made games and students who did not. Barbour, Kinsella, and Rieber (2011) conducted a similar study in a U.S. history class and also found no statistically significant difference in performance.

Siko et al. (2011) conducted the largest study to date using homemade PowerPoint games, using approximately 150 students enrolled in an environmental chemistry course. The researchers not only analyzed the performance on two separate unit tests (i.e., by comparing the performance of those who created games and those who did not on two separate occasions), they examined whether creating tests on multiple occasions improved performance (i.e., if repeated exposure to the treatment had any effect). Similar to the previous studies, there was no statistically significant difference in performance on either unit test. When the researchers examined at the scores on the second unit test, they found that the students who created games for both units performed better than the students who only made the games on one occasion and then those who never created the games at all. However, the difference was not statistically significant.

Barbour et al. (2009) tested the assumption that students were writing higher-order questions, one of the justifications of homemade PowerPoint games, by analyzing the questions

written by students in the Barbour et al. (2011) study. In their analysis of over 1,900 questions, the authors found the overwhelming majority of questions (i.e., 94%) were “Knowledge” level questions, which is the simplest form of question based on Bloom’s (1956) taxonomy. Further, none of the questions were above the “Application” level. Barbour and his colleagues suggested that this may be the reason why the studies on the effect of homemade PowerPoint games on student performance conducted up to that point have not shown statistical differences.

In summary, while the literature supports each of the three philosophical justifications individually for the use of homemade PowerPoint games, studies involving the games themselves have not shown any statistical difference in performance. This fact has led researchers begin to examine whether the games are truly demonstrating these justifications and, in particular, whether students are writing higher-order questions. As a follow-up to both the Barbour et al. (2009) and Siko et al. (2011) studies, I am looking to see the range of student generated questions based on Bloom’s taxonomy when creating homemade PowerPoint games for an environmental chemistry course.

Methodology

The purpose of this study was to analyze the questions written by students for the homemade PowerPoint games they created in the Siko et al. (2011) study to determine where they belonged on Bloom’s taxonomy. In keeping with the findings of Rosenshine et al. (1996), students should be able to write more higher-order questions with continued practice. Therefore, my two research questions were as follows:

1. How many questions from each level of Bloom’s taxonomy did students write for each of the two games in the Siko et al. (2011) study?

2. Did students who created games twice write more higher-order questions than students who only created games once on the second unit project?

For the second question, I developed the following hypotheses:

H₀: No difference in the number of questions from each level.

H₁: Students who created games on two occasions wrote more higher order questions than students who only created games once.

In order to answer the first research question, I followed a protocol similar to the protocol used in Barbour et al. (2009) study.

Two subject matter experts (i.e., teachers in the school used in the study who taught the course) viewed each game and then coded each question to determine which level on Bloom's taxonomy the question belonged. For each unit, the subject matter experts coded three games individually, and then compared their results to clarify any questions they had with the application of Bloom's taxonomy. After comparing their results and rectifying any problems or questions they had, they went on to code the remainder of their games individually. The results from both coders were tallied by both total number and percentage from each level on the taxonomy; thus, the total number of questions listed is twice the number of actual questions written by students. Inter-rater reliability was also calculated as a percentage of questions scored the same by both coders.

To answer the second research question, I examined questions written by students on the game project for the second unit. I compared the number of "Knowledge" level questions written by students who created games twice versus students who only created games once. To test the hypothesis, I used an independent *t*-test to see if the students who created games twice wrote fewer "Knowledge" level questions.

Participants and Setting

The games analyzed in the study were created by students at a large, Midwestern high school during the 2008-2009 school year. The course for which the students created games was entitled environmental chemistry. The course was based on the American Chemical Society's *Chemistry in the Community* curriculum, also known as *ChemCom*. The *ChemCom* curriculum is different than a traditional high school chemistry course in several ways. First, the curriculum emphasizes the more practical aspects of chemistry that most people would see in everyday life (American Chemical Society, 2008). For example, instead of units on stoichiometry and gas laws, the ChemCom curriculum has units on water quality, petroleum, and air quality. Second, the course has less emphasis on both memorization and mathematic problem-solving than a traditional chemistry course. Finally, the course is geared toward college-bound student who do not intend to pursue a career in science or engineering.

The school where the games were created utilized a trimester system, with the course being two trimesters in length. The students did not have to have the course in successive trimesters (i.e., students could be enrolled during the first and second, the second and third, or the first and third trimesters). The first unit test occurred during the first half of the course, and the second unit test occurred in the second half of the course. Students also did not necessarily have the same teacher for both halves of the course. Since only one of the three teachers who taught the course during the 2008-2009 school year had the students create games for the class, it was possible that students created games for both units, for the second unit only, or not at all. The first unit that homemade PowerPoint games were made was on natural resources, the

periodic table, mining, and processing metals. The content for the second unit revolved around atmospheric conditions, properties of gases, and the gas laws.

For both units, the students followed a protocol which consisted of four consecutive days in the computer lab. On the first day, students were introduced to the project by playing sample games downloaded from the homemade PowerPoint game website (<http://it.coe.uga.edu/wwild/pptgames/>) and discussing the attributes found in high-quality, interesting games. While working in groups of two or three students, they also began brainstorming ideas for narratives and questions. On the second and third days, the students developed questions for the game and started to construct the game from a template downloaded from the homemade PowerPoint game website. On the final day, students finished their games and played the games created by other students. Shortly thereafter, the students took a test on the unit.

Results

The first research question asked how many higher order questions did students write on each test. Two subject matter experts (i.e., teachers at the school who frequently taught environmental chemistry at the school) analyzed each of the questions written by students. In order to maintain inter-rater reliability, the subject matter experts coded two games individually, and then compared their results. When they differed on their analysis of the questions, they discussed the reasoning for their choice and came to a consensus. After that initial meeting, they coded the rest of the game questions individually. After analyzing 1,250 questions, the majority of the questions were judged to be knowledge level questions. Table 1 summarizes our results for the first unit on materials and resources.

Table 1

Percentage of questions written rated from each level of Bloom's taxonomy on the first unit test

Level	Number of Questions	Percentage of Questions
Knowledge	760	60.8%
Comprehension	285	22.8%
Application	205	16.4%
Total	1,250	100.0%

Analysis of the ranking showed an 85.8% inter-rater reliability. No questions were ranked higher than "Application" on Bloom's taxonomy.

For the second unit, for which students created games on the topic of gases and the atmosphere, the questions were analyzed by the same subject matter experts. However, in an attempt to improve the inter-rater reliability, the subject matter experts practiced by first coding one game together, followed by coding two additional games individually, and then meeting to come to a consensus on the two additional games. The rest of the games were then coded individually. As a result, the inter-rater reliability improved to 96.4%. The results are summarized in Table 2.

Table 2

Percentage of questions written rated from each level of Bloom's taxonomy on the second

unit test

Level	Number of Questions	Percentage of Questions
Knowledge	890	67.4%
Comprehension	216	16.3%
Application	216	16.3%
Total	1,322	100.0%

Again, no questions were ranked above the level of “Application” and the majority of the questions were rated as declarative knowledge questions.

To answer the second research question, I examined questions created by students for games on the second unit. I compared the number of knowledge level questions written by students who created games for both units with those who only created games for this unit project. There were 14 groups who created games for only the second unit, while 16 groups created games for both units. Most groups contained two members, but several groups contained three, because of students being absent or an odd number of people in the class. The game project called for each group member to write ten questions; thus, most games consisted 20 or 30 questions. However, some groups wrote fewer than the required number of questions, and other groups wrote more than the required number. Therefore, I compared the percentage of questions that were “Knowledge” level in each game as opposed to the total number of questions. The results are summarized in Table 3.

Table 3

Percentage of questions for each game rated as “Knowledge” level

Group	N	Mean	SD
First time with games	14	70.7	10.1
Second time with games	16	64.6	10.5

As we can see, groups who only created games on one occasion wrote a higher percentage of “Knowledge” level questions than groups who created games for both units. In other words, the group who created games for both units wrote a greater percentage of higher-order questions. However, the difference was not determined to be statistically significant, $t(28) = 1.60$; $p = .12$.

Discussion

The results of the question analysis, along with the results of the study from which the data came (Siko et al., 2011) mirror the results of the Barbour and his colleagues (Barbour, Clesson et al., 2011; Barbour, Kinsella et al., 2011) studies. That is, both studies showed no statistical difference in performance between groups who made games and those who did not, as well as the fact in both studies the students wrote a majority of “Knowledge” level questions. Barbour et al. (2009) believed that the high proportion of “Knowledge” level questions may have been a reason for the no statistical difference findings. Harper, Etkina, and Lin (2003) also found that it was not the number of questions written, but the number of quality questions written by students that influenced performance. However, the deeper question becomes why the students are not writing more higher-order questions in the first place, and whether any of the

three justifications are actually being met with the current protocol for a game design project using homemade PowerPoint games.

One of the problems may lie in the way the game projects have been conducted in the first place. They have been used as review for an assessment. Siko et al. (2011) questioned whether this actually constituted constructionism. In other words, can a review and the actual learning of the content be considered the same with respect to constructionism? Perhaps if the game project was part of the actual content delivery, or if the games were constructed throughout the unit, rather than at the end, one could make a stronger case that the game design project is indeed constructionism.

The literature involving writing across the curriculum and microthemes stated that repetition were helpful in allowing students to write better (Garner, 1994). Students are writing short statements for the theme, a technique supported by Bangert-Drowns et al. (2004), but for the most part the act of writing a narrative was a one-time event. However, while these issues may exist with application of the homemade PowerPoint games and how adequately they satisfy their philosophical justifications of constructionist pedagogy and microtheme writing, it is doubtful that these deficiencies affected the students' ability to write more higher-order questions.

With regards to question writing strategies, Wong (1985) noted that the effects of the technique could be enhanced if more instruction was given on how to write questions and if an emphasis was placed on writing higher-order questions. Chin and Osborne (2008) also found that students needed sufficient instruction through prompts, scaffolding and modeling to be successful. By spending all of their time in the computer lab, it makes it difficult for a teacher to teach the technical aspects of the project, have the students be introduced to game design with an

orientation to homemade PowerPoint games, work on constructing the game, and complete the project, let alone find time to provide adequate instruction on writing questions to the students.

Furthermore, Papert (1980) believed that a key component of learning through programming was the aspect of debugging, or fixing errors in the program. While the current protocol seemed to provide adequate time for debugging the *MS PowerPoint* file itself, it did not allow the teacher time to provide feedback to the students. The researchers in the Siko et al. (2011) study noted this as a potential reason for their no significant difference finding. Perhaps the lack of adequate feedback not only led to no difference in student performance, but also led to students not having time to revise their questions – or even know their questions needed to be revised – to move them to higher levels on Bloom’s taxonomy. Lotherington and Ronda (2010) found that time to feedback, revision, and the ability to critique and edit the questions of classmates were important to the learning process. While students in the homemade PowerPoint game studies were able to play and provide feedback on the games as a whole, perhaps more time should be devoted to providing peer feedback on student questions, which are the main component of the content on which students are tested.

In line with previous research on the questions written by students for review games, the majority of the questions were factual recall questions. Students who had previous experience creating games did write more higher-order questions than those without prior experience, but the difference was not statistically significant. Based on speculation from previous studies, this may be a reason for the lack of statistical significance in student performance on tests. Based on the research on question-writing strategies, the lack of higher-order questions written by students may stem from the lack of structure and time afforded to the project. In particular, there was a

lack of instruction and instructional supports for teaching the process of writing questions. There was also little time allotted for feedback and revision of the questions.

Conclusion and Implications

In this study, I have looked at the ability of students to write quality, higher-order questions for a game design project involving homemade PowerPoint games. While the students did write more higher-order questions than a previous study involving an analysis of game questions, the majority of the students' questions were still "Knowledge" level questions requiring only memorization and recall on the part of the player to succeed in the game. Furthermore, students who created games on multiple occasions did write more higher-order questions than students who only created games only once; however, the difference was not statistically significant.

Several recommendations for practitioners wanting to conduct a game design project can be suggested based on the results of this study. As Siko et al. (2011) originally noted, it may be better to implement the games as a unit project rather than simply a review tool. Also, researchers (e.g., (Chin & Osborne, 2008; Lotherington & Ronda, 2010)) suggested that more structure be provided when implementing the project. Based on the results of this study, I recommend that more structure be provided with respect to teaching students how to write questions. In particular, students will need more instruction on how to write higher-order questions and how to revise "Knowledge" level questions to increase their difficulty on Bloom's taxonomy. Students should also have the opportunity to obtain feedback on their questions from the teacher and, if possible, have students revise one another's questions as well.

Future research should examine whether the aforementioned suggestions increase the number of higher-order questions written by students, and also whether the additional structure increases the performance of students who create homemade PowerPoint games. The changes in structure would also affect how the overall instruction is designed for the unit. Four days in a computer lab prior to a test is quite different than spreading that time out over the course of a unit. Students may receive instruction on question writing and time to write the questions in the classroom rather than the computer lab. From a design perspective, researchers could examine the design decisions made by a classroom teacher to intertwine the game project throughout the unit rather than at the end. In the end, the game itself would shift from a simple review tool to a driving question or artifact in a project-based science unit, which could erase any questions raised on whether homemade PowerPoint games are truly rooted in constructionist pedagogy.

REFERENCES

- Aldrich, C. (2005). *Learning by doing: the essential guide to simulations, computer games, and pedagogy in e-learning and other educational experiences*. San Francisco, CA: Pfeiffer.
- Ambrosio, J. (1987). Writing to improve learning in biology. *Journal of College Science Teaching*, 16(4), 4.
- American Chemical Society. (2008). *Chemistry in the Community (ChemCom): Frequently Asked Questions*. Retrieved from http://portal.acs.org/portal/acs/corg/content?_nfpb=true&_pageLabel=PP_ARTICLEMAIN&node_id=557&content_id=CTP_005518&use_sec=true&sec_url_var=region1&__uuid
- Andrews, M. H., & Andrews, L. (1979). First-year chemistry grades and SAT math scores. *Journal of Chemical Education*, 56(4), 231-232.
- Avraamidou, L., & Osborne, J. (2009). The role of narrative in communicating science. *International Journal of Science Education*, 31(12), 1683-1707.
- Bangert-Drowns, R. L., Hurley, M., & Wilkinson, B. (2004). The effects of school-based writing-to-learn interventions on academic achievement: A Meta-Analysis. *Review of Educational Research*, 74(1), 29-58.
- Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *The Journal of the Learning Sciences*, 13(1), 1-14.
- Barbour, M., Clesson, K., & Adams, M. (2011). Game design as an educational pedagogy. *Illinois English Bulletin*, 98(3), 7-28.

- Barbour, M., Kinsella, J., & Rieber, L. (2011). Secondary students, laptops and game design: Examining the potential of homemade PowerPoint games in a blended learning environment. *Georgia Social Studies Journal*, 1(2), 31-44.
- Barbour, M., Kromrei, H., McLaren, A., Toker, S., Mani, N., & Wilson, V. (2009). *Testing an assumption of the potential of homemade PowerPoint games*. Paper presented at the Proceedings of the Annual Conference of the Society for Information Technology and Teacher Education, Norfolk, VA.
- Barbour, M., Rieber, L. P., Thomas, G. B., & Rauscher, D. (2009). Homemade PowerPoint Games: A Constructionist Alternative to WebQuests. *TechTrends*, 53(5), 54-59.
- Barbour, M., Thomas, G., Rauscher, D., & Rieber, L. (2010). Homemade PowerPoint games. In A. Hirumi (Ed.), *Playing Games in Schools* (pp. 333-347). Washington, DC: International Society for Technology in Education.
- Barbour, M., Thomas, G. B., Rauscher, D., & Rieber, L. P. (2008). Homemade PowerPoint games: Preparing the next generation of teachers to use creative design activities in the classroom. In A. Hirumi (Ed.), *Digital video games for PreK-12 education: Engaging learners through interactive entertainment*. Washington, DC: International Society for Technology in Education.
- Barthel, M. G. (2001). *The relationship between beginning college chemistry achievement and prior knowledge, number of college mathematics courses completed, GPA of college mathematics courses completed, levels of Piagetian intellectual development, mathematics ACT score, science ACT score, and composite ACT score*. Ph.D. 3025598, University of Missouri - Columbia, United States -- Missouri. Retrieved from

<http://proxy.lib.wayne.edu/login?url=http://proquest.umi.com/pqdweb?did=725984231&Fmt=7&clientId=14288&RQT=309&VName=PQD>

- Berry, J. W., & Chew, S. (2008). Improving learning through interventions of student-generated questions and concept maps. *Teaching of Psychology, 35*(4), 305-312.
- Betrus, A., & Botturi, L. (2010). Principles of playing games for learning. In A. Hirumi (Ed.), *Playing games in school: Video games and simulations for primary and secondary education*. (pp. 33-56). Washington, DC: International Society for Technology in Education.
- Bishop-Clark, C., Courte, J., Evans, D., & Howard, E. (2007). A quantitative and qualitative investigation of using Alice programming to improve confidence. *Journal of Educational Computing Research, 37*(2), 193-207.
- Bloom, B. (1956). *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain*. . New York: McKay.
- Bogdan, R., & Biklen, S. (2007). *Qualitative Research for Education: An Introduction to Theories and Methods* (5th ed.). Boston, MA: Allyn and Bacon.
- Carnegie Mellon University. (2011). Alice. Retrieved from <http://www.alice.org>
- Chandran, S., Treagust, D. F., & Tobin, K. (1987). The role of cognitive factors in chemistry achievement. *Journal of Research in Science Teaching, 24*(2), 145-160.
- Chen, X., & Kaufman, P. (1997). *Risk and resilience: The effects of dropping out of school*. . Paper presented at the Annual meeting of the American Association of Educational Research, Chicago, IL.
- Chin, C., & Osborne, J. (2008). Students' questions: a potential resource for teaching and learning science. *Studies in science education, 44*(1), 1-39.

- Collins, M. A. J. (2000). *Do microthemes improve student learning of biology*. Paper presented at the National Science Teachers Association National Convention, Orlando, FL.
- Deavor, J. (2001). Who wants to be a (chemical) millionaire? *Journal of Chemical Education*, 78(4), 467.
- Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, 32(1), 5-8.
- Dickey, M. (2006). Game design narrative for learning: Appropriating adventure game design narrative devices and techniques for the design of interactive learning environments. *Educational Technology Research and Development*, 54(3), 245-263.
- Ferguson, C. J. (2010). Blazing angels or resident evil? Can violent video games be a force for good? *Review of general psychology*, 14(2), 68-81.
- Foster, A., & Mishra, P. (2009). Games, claims, genres, and learning. *Gaming and simulations: Concepts, methodologies, tools, and applications*. Hershey, PA: Information Resources Management Association.
- Garner, R. M. (1994). An efficient approach to writing across the curriculum: Microthemes in accounting classes. *Journal of education for business*, 69(4), 211-216.
- Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment*, 1(1), 1-4.
- Glynn, S. M., & Muth, K. D. (1994). Reading and writing to learn science: Achieving scientific literacy. *Journal of Research in Science Teaching*, 31(9), 1057-1073.
- Gough, N. (1993). Environmental education, narrative complexity and postmodern science/fiction. *International Journal of Science Education*, 15(5), 607 - 625.

- Hair, J., Black, W., Babin, B., Anderson, R., & Tatham, R. (2006). *Multivariate Data Analysis* (6th ed.). Upper Saddle River, NJ: Pearson.
- Harper, K., Etkina, E., & Lin, Y. (2003). Encouraging and analyzing student questions in a large physics course: Meaningful patterns for instructors. *Journal of Research in Science Teaching, 40*, 776-791.
- Hayes, E. R., & Games, I. A. (2008). Making computer games and design thinking. *Games and Culture, 3*(3-4), 309-332.
- Hayes, E. R., Gee, J. P., Games, I., Torres, R. J., Peppler, K., Kafai, Y. B., . . . Briggs, K. (2008). *New perspectives on learning through (game) design*. Paper presented at the Proceedings of the 8th international conference on International conference for the learning sciences - Volume 3, Utrecht, The Netherlands.
- Hays, R. (2010). Making games more effective in the classroom. In A. Hirumi (Ed.), *Playing games in schools: Video games and simulations for primary and secondary education* (pp. 249-276). Washington, DC: International Society for Technology in Education.
- Herring, J. E. (2010). School students, question formulation and issues of transfer: A constructivist grounded analysis. *Libri (København), 60*(3), 218-229.
- Hirumi, A. (Ed.). (2009). *Playing games in school*. Washington, DC: International Society of Technology in Education.
- Hirumi, A., Appelman, B., Rieber, L. P., & Van Eck, R. (2010). Preparing instructional designers for game-based learning: Part 2. *TechTrends, 54*(4), 19-27.
- Hirumi, A., & Stapleton, C. (2008). Integrating fundamental ID tasks with game development processes to optimize game-based learning. In C. T. Miller (Ed.), *Games: Their purpose and potential in education* (pp. 127-162). New York: Springer.

- Jang, S. J. (2009). Exploration of secondary students' creativity by integrating web-based technology into an innovative science curriculum. *Computers and education*, 52(1), 247.
- Kafai, Y. (1998). Game design as an interactive learning environment for fostering students' and teachers' mathematical inquiry. *International Journal of Computers for Mathematical Learning*, 3(2), 149-184.
- Kafai, Y. (2001). *The Educational Potential of Electronic Games: From Games-To-Teach to Games-To-Learn*. Paper presented at the Playing by the Rules: The Cultural Policy Challenges of Video Games, Chicago, IL.
- Kafai, Y. (2006). Playing and Making Games for Learning: Instructionist and Constructionist Perspectives for Game Studies. *Games and Culture*, 1(1), 36-40.
- Kafai, Y., Ching, C. C., & Marshall, S. (1997). Children as designers of educational multimedia software. *Computers in Education*, 29(2), 117-126.
- Kafai, Y., Franke, M. L., Shih, J. C., & Ching, C. C. (1998). Game design as an interactive learning environment for fostering students' and teachers' mathematical inquiry. *International Journal of Computers for Mathematical Learning*, 3(2), 149-184.
- Kafai, Y., Peppler, K. A., & Chiu, G. M. (2007). High tech programmers in low-income communities: Creating a computer culture in a community technology center. In C. Steinfield, B. T. Pentland, M. Ackerman & N. Contractor (Eds.), *Communities and Technologies 2007* (pp. 545-563): Springer London.
- Kafai, Y., & Resnick, M. (Eds.). (1996). *Constructionism in Practice: Designing, Thinking, and Learning in a Digital World*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Kebritchi, M., & Hirumi, A. (2008). Examining the pedagogical foundations of modern educational computer games. *Computers & Education*, 51(4), 1729-1743.

- Keck, M. (2000). A final exam review activity based on the Jeopardy format. *Journal of Chemical Education*, 77(4), 483.
- Kenny, R., & Gunter, G. (2011). Factors affecting adoption of video games in the classroom. *Journal of Interactive Learning Research*, 22(2), 259-276.
- Khalili, N., Sheridan, K., Williams, A., Clark, K., & Stegman, M. (2011). Students designing video games about immunology: Insights for science learning. *Computers in the Schools*, 28(3), 228-240.
- Kirkpatrick, L. D., & Pittendrigh, A. (1984). A writing teacher in the physics classroom. *The Physics teacher*, 22(3), 159.
- Kirschner, P., Sweller, J., & Clark, R. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, Experiential, and inquiry-based teaching. *Educational Psychologist*, 41(2), 75-86.
- Kurland, D., & Pea, R. (1985). Children's mental models of recursive LOGO programs. *Journal of educational computing research*, 1, 235-244.
- Linn, R., & Gronlund, N. (2000). *Measurement and Assessment in Teaching* (8th ed.). Upper Saddle River, NJ: Prentice-Hall.
- Logo Foundation. (2000). What is Logo? Retrieved from <http://el.media.mit.edu/logo-foundation/logo/index.html>
- Lotherington, H., & Ronda, N. S. (2010). Gaming geography: Educational games and literacy development in the Grade 4 classroom. *Canadian Journal of Learning and Technology*, 35(3).

- Lukhele, R., Thissen, D., & Wainer, H. (1994). On the relative value of multiple-choice, constructed response, and examinee-selected items on two achievement tests. *Journal of Educational Measurement, 31*(3), 234-250.
- Maloney, J. H., Peppler, K., Kafai, Y., Resnick, M., & Rusk, N. (2008). *Programming by choice: urban youth learning programming with scratch*. Paper presented at the Proceedings of the 39th SIGCSE technical symposium on Computer science education, Portland, OR, USA.
- Mayer, R. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. *American Psychologist, 59*(1), 14-19.
- National Academy of Sciences. (1996). *National Science Education Standards*. Washington, DC: National Academy Press.
- Nitko, A. (2004). *Educational Assessment of Students* (4th ed.). Upper Saddle River, NJ: Pearson Merrill Prentice Hall.
- Norris, S., Guilbert, S., Smith, M., Hakimelahi, S., & Phillips, L. (2005). A theoretical framework for narrative explanation in science. *Science Education, 89*, 535-563.
- Nowosielski, D. (2007). Use of a Concentration game for environmental chemistry class. *Journal of Chemical Education, 84*(2), 239-240.
- Overmars, M. (2004). Teaching computer science through game design. *Computer (Long Beach, Calif.), 37*(4), 81-83.
- Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas*. New York: Basic Books.
- Papert, S. (1987). Computer Criticism vs. Technocentric Thinking. *Educational Researcher, 16*(1), 22-30.

- Papert, S. (1991). Situating constructionism. In I. Harel & S. Papert (Eds.), *Constructionism*. Norwood, NJ: Ablex.
- Parker, J. S. (2004). Evaluating the impact of project based learning by using student created PowerPoint games in the seventh grade language arts classroom. *Instructional Technology Monographs, 1*. Retrieved from <http://projects.coe.uga.edu/itm/archives/fall2004/JPARKER.HTM>.
- Pea, R., & Kurland, D. (1984). On the cognitive effects of learning computer programming. *New Ideas in Psychology, 2*, 137–168.
- Peppler, K. A., & Kafai, Y. (2007). From SuperGoo to Scratch: exploring creative digital media production in informal learning. *Learning, media and technology, 32*(2), 149-166. doi: 10.1080/17439880701343337
- Pickens, M., & Eick, C. (2009). Studying motivational strategies used by two teachers in differently tracked science courses. *The Journal of educational research (Washington, D.C.), 102*(5), 349-362.
- Prain, V., & Hand, B. (1996). Writing for learning in secondary science: Rethinking practices. *Teaching and teacher education, 12*(6), 609.
- Prensky, M. (2008). Students as designers and creators of educational computer games: Who else? *British journal of educational technology, 39*(6), 1004-1019.
- Prensky, M. (2010). Educating the Millennial Generation. In A. Hirumi (Ed.), *Playing Games in School* (pp. 7-32). Washington, DC: International Society for Technology in Education.
- Reeves, T. (1995). *Questioning the questions of instructional technology research*. Paper presented at the National Convention of the Association for Educational Communications and Technology, Anaheim, CA.

- Reeves, T., Herrington, J., & Oliver, R. (2005). Design research: A socially responsible approach to instructional technology research in higher education. *Journal of Computing in Higher Education, 16*(2), 97-116.
- Resnick, M. (2009). Scratch programming for all. *Communications of the ACM, 52*(11), 60. doi: 10.1145/1592761.1592779
- Reynolds, R., & Caperton, I. (2009). *Development of High School and Community College Students' Contemporary Learning Abilities in Globaloria-West Virginia*. Paper presented at the 2009 American Educational Research Association Annual Conference, San Diego, CA.
- Rice, J. W. (2006). *New media resistance: Barriers to implementation of computer video games in the classroom*. Paper presented at the American Educational Research Association Annual Meeting 2006, San Francisco, CA.
- Richey, R., Klein, J., & Tracey, M. (2011). *The Instructional Design Knowledge Base: Theory, Research and Practice*. New York: Routledge.
- Rickards, J. P., & DiVesta, F. J. (1974). Type and frequency of questions in processing textual material. *Journal of Educational Psychology, 66*(3), 354-362.
- Rieber, L. P. (2004). Microworlds. In D. H. Jonassen (Ed.), *Handbook of Research for Educational Communications and Technology* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum.
- Rieber, L. P. (n.d.). Homemade PowerPoint Games: A Constructionist Alternative to WebQuests Retrieved from <http://it.coe.uga.edu/wwild/pptgames/ppt-games-paper.html>

- Rieber, L. P., Barbour, M. K., Thomas, G. B., & Rauscher, D. (2008). Learning by designing games: Homemade PowerPoint games. In C. T. Miller (Ed.), *Games: Their purposes and potential in education* (pp. 23-42). New York: Springer.
- Rieber, L. P., Luke, N., & Smith, J. (1998). Project KID DESIGNER: Constructivism at work through play. *Meridian: A Middle School Computer Technologies Journal*, 1(1). Retrieved from www.ncsu.edu/meridian/jan98/index.html
- Robertson, J., & Howells, C. (2008). Computer game design: Opportunities for successful learning. *Computers & Education*, 50(2), 559-578.
- Rodger, S. H., Bashford, M., Dyck, L., Hayes, J., Liang, L., Nelson, D., & Qin, H. (2010). *Enhancing K-12 education with alice programming adventures*. Paper presented at the Proceedings of the fifteenth annual conference on Innovation and technology in computer science education, Bilkent, Ankara, Turkey.
- Rosenshine, B., Meister, C., & Chapman, S. (1996). Teaching students to generate questions: A review of the intervention studies. *Review of Educational Research*, 66(2), 181-221.
- Runyon, R., Coleman, K., & Pittenger, D. (2000). *Fundamentals of Behavioral Statistics* (9th ed.). Boston, MA: McGraw-Hill.
- Schmidt, S. J., Parmer, M. S., & Javenkoski, J. S. (2002). Sharing our experiences with writing-for-learning techniques in a large introductory course: The daily microtheme. *Journal of Food Science Education*, 1(2), 28-33.
- Sheridan, K., Clark, K. C., & Peters, E. (2009). *How scientific inquiry emerges from game design*. Paper presented at the Society for Information Technology & Teacher Education International Conference 2009, Charleston, SC, USA. Retrieved from <http://www.editlib.org/p/30835>

- Siko, J. P. (2011). *Using PowerPoint as a game design tool in science education*. Paper presented at the Annual conference of the Canadian Network of Innovation in Education, Hamilton, ON.
- Siko, J. P., & Barbour, M. (2011). *Furthering the Use of Homemade PowerPoint Games in K-12 Education*. Paper presented at the Association for Educational Communications and Technology International Convention, Jacksonville, FL.
- Siko, J. P., & Barbour, M. (2012). *Design research using game design as an instructional tool*. Paper presented at the Society for Information Technology and Teacher Education International Conference, Austin, TX.
- Siko, J. P., Barbour, M. K., & Toker, S. (2011). Beyond Jeopardy and lectures: Using Microsoft PowerPoint as a game design tool to teach science. *Journal of Computers in Mathematics and Science Teaching, 30*(3), 302-320.
- Simpkins, S., Davis-Kean, P., & Eccles, J. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental psychology, 42*(1), 70.
- Smith, P., & Ragan, T. (2005). *Instructional design* (3rd ed.). Hoboken, NJ: John Wiley & Sons, Inc.
- Squire, K. (2006). From content to context: Videogames as designed experience. *Educational Researcher, 35*(8), 19-29.
- Stanley, L. C. (1991). Writing-to-learn assignments: The journal and the microtheme. *New Directions for Community Colleges*(73), 245-250.
- Stewart, T., Myers, A., & Culley, M. (2010). Enhanced learning and retention through "Writing to Learn" in the psychology classroom. *Teaching of Psychology, 37*(1), 46-49.

- Sung, K., Shirley, P., & Rosenberg, B. R. (2007). Experiencing aspects of games programming in an introductory computer graphics class. *SIGCSE Bull.*, 39(1), 249-253.
- Tai, R. H., Ward, R. B., & Sadler, P. M. (2006). High school chemistry content background of introductory college chemistry students and its association with college chemistry grades. *Journal of Chemical Education*, 83(11), 1703-1711.
- Wong, B. Y. (1985). Self-questioning instructional research: A review. *Review of Educational Research*, 55(2), 227-268.

ABSTRACT

**CHANGING THE WAY WE BUILD GAMES: A DESIGN-BASED RESEARCH STUDY
EXAMINING THE IMPLEMENTATION OF HOMEMADE POWERPOINT GAMES IN
THE CLASSROOM**

by

JASON PAUL SIKO

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Advisor: Michael Kristopher Barbour**Major:** Instructional Technology**Degree:** Doctor of Philosophy

This design-based research study examined the effects of a game design project on student test performance, with refinements made to the implementation after each of the three iterations of the study. The changes to the implementation over the three iterations were based on the literature for the three justifications for the use of homemade PowerPoint games in the classroom: constructionism, microthemes, and question writing. A review of the literature for the justifications found that the game project, as implemented in previous studies using homemade PowerPoint games, did not align well with the rationale for their use. After three iterations of the study, students who created homemade PowerPoint games did perform better on assessments than students who either did not create games, created games as a review, or created games as part of an unstructured unit project. However, these differences were not statistically significant. As part of the third iteration, two of the individual justifications were tested in isolation to determine whether gains could be seen without creating games. While the students who were part of interventions involving microthemes and question writing did perform better

than students who did not receive the interventions, the differences were not statistically significant. Future research in the area of game design as an instructional tool should look to replicate these studies, as some of the sample sizes were small. Future research should also examine additional changes to the implementation of a game design project, including the use of other game design environments.

AUTOBIOGRAPHICAL STATEMENT

JASON PAUL SIKO

With the exception of one wonderful year out-of-state, I am a born and bred Michigander. I was raised in the area of suburban Detroit known as "Downriver," which is an often misunderstood place, both in terms of its location and culture. It is a traditionally blue-collar area where the majority of people are employed in the automotive industry.

I was valedictorian of my high school graduating class at Southgate Anderson High School, and from there went to the University of Michigan. I went through the usual major-of-the-month during my first few years of college, but was almost always headed toward something in science. I graduated with a degree in biology, and after deciding against medical school (I never applied to any, so I can't say I was rejected...nor could I say I was a lock to get in), I obtained my teaching certificate the following year.

I have been employed at Clarkston High School since 1998. I have taught various courses in biology and chemistry, both advanced and remedial. However, I started to get an itch to try something new, and for the 2006-2007 school year my district granted me a leave so I could pursue a degree in Futures Studies at the University of Houston, one of three colleges which grants such a degree. The following summer I was an intern at the Institute of Alternative Futures, a leading futures consulting firm in the Beltway. Undecided on my career path (i.e., there were not many futures jobs at the time, and I was not set on jumping right into a doctoral program), I returned to teaching the following fall. After taking a year off of my own schooling, I began my doctorate in Instructional Technology at Wayne State University.