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

Grimpent-ils la pyramide? Évaluation des questions produites par les étudiants dans un projet de conception de jeux

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Abstract

Researchers have examined the use of homemade PowerPoint games as an instructional technique to improve learning outcomes. However, test data have shown no significant difference in performance between high school chemistry students who created games and students who did not (Siko, Barbour, & Toker, 2011). One of the justifications for the use of the games is that students will, with practice, write higher-order questions when constructing the games. Two subject matter experts rated over 2,500 questions from games created by students in an environmental chemistry class through thematic analysis using Bloom's taxonomy as a coding scheme. The students wrote primarily recall questions, and students who created games on two occasions did not write more questions than students who only created games once. This suggests that changes to the question-writing aspect of the game project may be necessary in order to see improvements in achievement when compared to control groups.

Keywords: constructionism, homemade PowerPoint games, question writing, game design

Résumé

Les chercheurs ont étudié l'usage de jeux PowerPoint maison en tant que technique pédagogique visant à améliorer les résultats d'apprentissage. Les données des tests n'ont toutefois révélé aucune différence significative quant au niveau de performance des étudiants du secondaire en chimie ayant créé des jeux et celui des étudiants n'en ayant pas conçus (Siko, Barbour, et Toker, 2011). L'utilisation des jeux est notamment justifiée par l'idée que, pratique aidant, les étudiants écrivent des questions plus complexes lorsqu'ils élaborent des jeux. Au moyen d'une analyse thématique utilisant la taxonomie de Bloom comme système de codification, deux experts chimistes ont évalué plus de 2500 questions provenant de jeux conçus par des étudiants d'une classe de chimie environnementale. Les étudiants ont rédigé principalement des questions faisant appel à la mémoire, et les étudiants ayant créé des jeux à deux reprises n'ont pas produit davantage de questions que ceux qui en étaient à leur première expérience de création de jeux. Il appert que des changements à la rédaction des questions sont requis au projet de jeux pour pouvoir améliorer la performance par rapport aux groupes témoins.

Mots-clés: constructionnisme, jeu PowerPoint maison, élaboration de questions, conception de jeux

Introduction

Designing games can be a difficult endeavor, and designing educational games has the added layer of including educational objectives in the design (Hirumi, Appelman, Rieber, & Van Eck, 2010). In order for a game to be considered good, it 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 (Barbour, Thomas, Rauscher, & Rieber, 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 examining the use homemade PowerPoint games as an instructional strategy have listed three philosophical justifications for their use: constructionist pedagogy, writing across the curriculum, and student-generated questioning strategies (Barbour, Rieber, Thomas, & Rauscher, 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 and were exposed to more traditional methods of instruction (Barbour, Clesson, & Adams, 2011; Barbour, Kinsella, & Rieber, 2011; Parker, 2004; Siko, Barbour, & Toker, 2011). These findings have 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 describe homemade PowerPoint games and detail the implementation of the project in the classroom. I follow this with a review of the literature supporting the philosophical justifications for their use. After reviewing studies involving homemade PowerPoint games, I will share the findings 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 by students using *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). The template includes an introductory slide as well as slides for the game narrative, directions, and objectives. The rest of the game, including the question slides and linkages between those slides (i.e., via the action button feature in *MS PowerPoint*) is constructed by the students. 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, an example of which is shown in Figure 1.

***Figure 1.* A typical introductory slide to a homemade PowerPoint game**

Students generate a narrative slide, which provides the story behind the game. Students also generate slides that tell players how to play the game and how the game ends (i.e., how a player wins the game). Examples of these are shown in Figure 2 and Figure 3. In this game, an external game board is used in conjunction with the PowerPoint file.

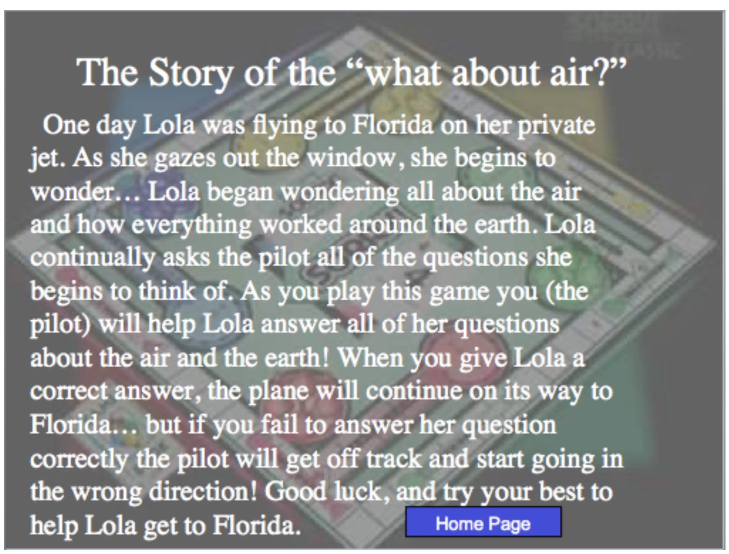

***Figure 2.* A narrative slide for a typical homemade PowerPoint game.**

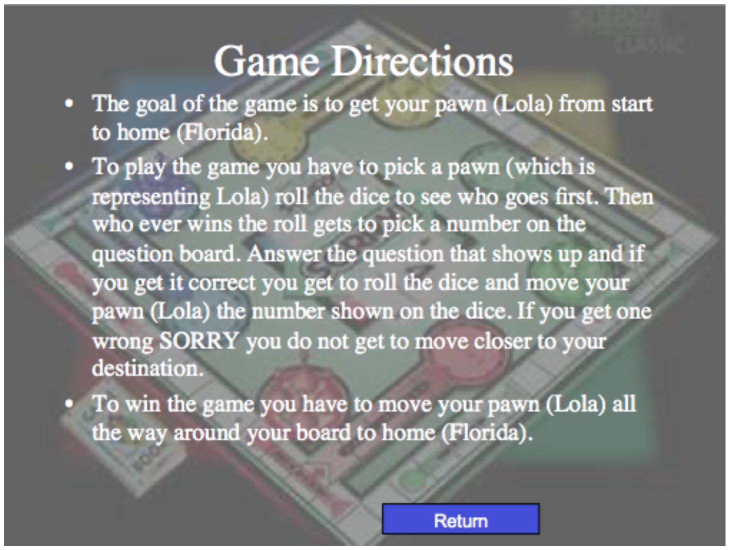

***Figure 3.* A homemade PowerPoint game slide that describes how to play the game.**

The game itself is usually played by answering a series of multiple choice questions related to some content. Figure 4 is an example of a question related to the direct relationship between volume and absolute temperature.

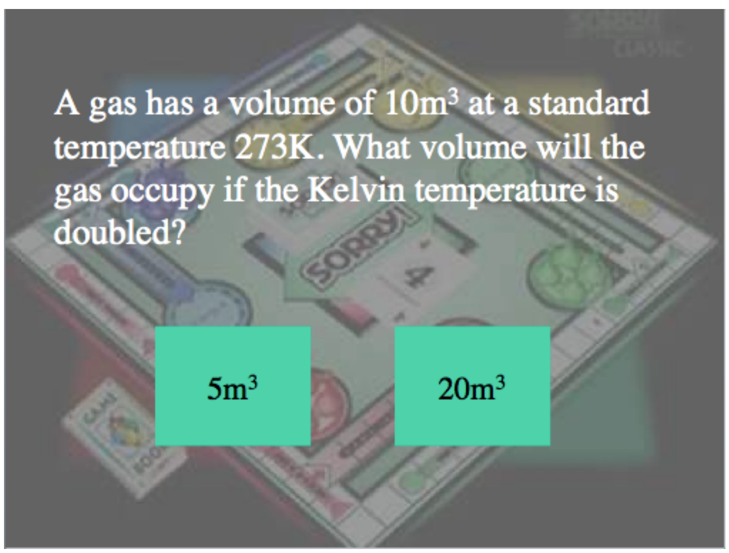

***Figure 4.* An example of a question in a homemade PowerPoint game.**

For this question, the correct answer is 20m^3. Clicking on this answer would direct the student playing the game to another slide indicating that the player is correct and instructing the player to proceed. Clicking on the other answer would have a negative consequence (e.g., loss of turn, moving backwards, etc.).

There are three justifications for using homemade PowerPoint games as an instructional tool: constructionism, microtheme writing, and question writing. First, the design of games is consistent with constructionist pedagogy; the idea that students effectively learn through the construction of some artifact (Papert, 1980). 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, Ching, & Marshall, 1997; Peppler & Kafai, 2007). While programming in *MS PowerPoint* does not require the same level of cognitive demand as the aforementioned languages, constructing the games requires some level of skill (e.g., planning the sequence of slides, inserting links correctly, debugging the game of errors, etc.) with the software application. Proponents argue that the simplicity, as well as the availability of *MS PowerPoint* in schools, is a distinct advantage over using other programming languages as tools in subject areas outside of computer science (Barbour, Kinsella, & Rieber, 2011). 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. One form of writing assignment that focuses on brevity and revision is called 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.

For a homemade PowerPoint game to be challenging, students have to create coherent questions that not only contain the right answer, but also 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 (Piaget, 1926), since the formation of questions help to integrate new information with current schema. Wong's analysis of studies that 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 more higher-order 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 (i.e., students that neither constructed nor played games) 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 secondary 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 secondary 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 a secondary 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, Kromrei, 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, Kinsella, and Rieber (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 finding 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 to 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, Kromrei, et al. (2009) and Siko et al. (2011) studies, I am examining 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 write more higher-order questions with continued practice. Therefore, the two research questions for this study 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?

The first research question is descriptive in nature; however, for the second question, I developed the following hypotheses:

H_0: No difference in the number of questions from each level.

H_1: Students who created games on two occasions wrote more higher order questions than students who only created games once.

Data Analysis

In order to answer the first research question, I followed a protocol similar to the protocol used in the Barbour, Kromrei, 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. Prior to their coding, the subject matter experts were given background materials on Bloom's taxonomy as well as material related to the Barbour et al. (2009) study. A "Knowledge" question was one that simply asked the student to recall some fact presented in the content of the chapter. A "Comprehension" question required the student to use some combination of facts in developing the answer. Finally an "Application" question required students to use existing knowledge in a novel situation. Examples of actual student questions are listed below:

- Knowledge: *What is the relationship between frequency and wavelength?*
- Comprehension: *Why are greenhouse gases in our atmosphere necessary for our survival?*
- Application: *You have 500L of a gas at 2atm at 273K. You change the temperature to 293K. What is the new pressure if volume stays constant?*

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. Inter-rater reliability was 85.8% for the first unit test. 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 for the second unit were then coded individually. As a result, the inter-rater reliability improved to 96.4% for the second unit test.

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 questions analyzed in the study were from games created by students at a large, Midwestern U.S. 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. Both tests came near the end of their respective trimester. 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 that 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 examined how many higher order questions students wrote on each test. After coding 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%

As previously mentioned, 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, where students created games on the topic of gases and the atmosphere, the questions were analyze by the same subject matter experts. As previously mentioned, 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 knowledge questions.

To answer the second research question, data from the second unit were categorized based on whether the students created games for either both units or just the second unit. Comparisons were made between the percentages of knowledge questions in each game rather than total number of questions. 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, it was necessary to analyze the data based on percentages rather than total number. 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

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 this study show that in a game design project in an environmental chemistry class, the questions generated by students were primarily knowledge-level questions. This was the case for games created for both units where the game design project was used. Further, on the second unit test there was no statistical difference in the percentage of knowledge-level questions between groups of students who created games where students created games on two occasions and those who only created games once.

These results, 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, & Adams, 2011; Barbour, Kinsella, & Rieber, 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, Kromrei, 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 be 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 future studies could examine student performance when the game project was part of the actual content delivery, or if the games were constructed throughout the unit, rather than at the end. This would 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 while creating a homemade PowerPoint game 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.

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