A Preliminary Examination of a Gamified Course to Address Affective Domain Issues in Learning Statistics

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Abstract

Online statistics courses in higher education are frequently a source of anxiety for students. While there have been many studies conducted on the cause of math anxiety and anxiety in computer-based learning, few studies have focused on statistics anxiety in an online course. This study examines whether students’ anxiety could be lowered by using gamification and Mayer’s Multimedia Principles in an asynchronous, online statistics course. Previous studies showed that by adding elements of gamification to a learning environment, anxiety could be lowered. By adding game elements like storyline, boss battles, applied equipment, and achievement levels, the original online statistics course was redesigned to become Stats Kwon Do, a martial-arts, gamified course.

Other research has shown that certain multimedia principles such as segmenting, personalization, and coherence could relieve learners’ anxiety. In the redesigned course, these and other multimedia principles were incorporated. Two groups of students over the course of two semesters completed the redesigned Stats Kwon Do course. At the end of each week, students provided reflective feedback on how they felt about the course and note areas that needed improvement. After analyzing the over 400 student comments, the findings offered guidance as to which redesigned components of the course reduced anxiety. During the first two weeks of the course, gamification was regularly cited by students as reducing anxiety. Overwhelmingly, students noted that certain multimedia principles made the biggest difference in lowering their anxiety, specifically, shorter videos (segmenting), repeated opportunities to learn and practice the material, and the use of visual elements.

Introduction

Statistics courses are a valuable and necessary component of degree completion in higher education. Graduate students are required to take statistics to ensure they use proper methods for
collecting data, apply correct analyses, and present effective results. These courses also ensure graduate students can evaluate and interpret the research of their peers. Beyond the classroom, the ability to understand and use statistics is of high value in many fields, as it offers foundations for making informed decisions which could have large impacts within an organization and for its stakeholders (Gal & Ginsburg, 1994).

With such a high value connected to understanding and using statistics, one would assume statistics would be a popular course at the graduate level. However, though required in most graduate programs, just the opposite is found: Students often approach statistics courses with anxiety. Because of this anxiety associated with taking a statistics course, statistics courses have been viewed as “obstacles” to a desired degree. DeVaney’s (2010) study showed that the presence of a required statistics course sometimes resulted in students changing to an entirely different program of study that did not have a statistics requirement.

**Literature Review**

In the 1980s, research was conducted on the effect of anxiety on learning. These studies showed that learners with high anxiety performed at lower levels in academic courses (Bandura, 1982). In the years following, studies showed a strong correlation between math anxiety and poor math performance. (McLeod, 1989; Hembree, 1990; Peterson & Fennema, 1985; Kloosterman, 1989; Grootenboer & Marshman, 2015). In 1990, testing of students while reducing their anxiety showed that, when math anxiety was reduced, higher achievement was consistently achieved (Hembree).

Anxiety, as defined by Spielberger (1966), can refer to anxiety that is innately part of one’s personality (Trait anxiety) or to anxiety that fluctuates depending upon a transitory situation (State anxiety) such as increased task difficulty. This author defined Trait Anxiety as “a motive or acquired behavioral disposition that predisposes an individual to perceive a wide range of objectively non-dangerous circumstances as threatening, and respond to these with A-State reactions disproportionate in intensity to the magnitude of the objective danger”, and he defined State Anxiety as “subjective, consciously perceived feelings of apprehension and tension accompanied by or associated with activation or arousal of the autonomic nervous system” (Spielberger, 1966).

Since the time of Spielberger’s studies, the most widely accepted basis for gathering data on transitory (State) anxiety has been through an individual’s honest introspection or qualitative data (Spielberger, 1966; Cambre & Cook, 1985). Wolpe noted that anxious responses can be highly individualized, and one student may have anxiety because of a previous experience with and reactions to specific stimuli, like an online statistics course (1981).

In the 1970s, Tobias did significant testing of the effect of different instructional methods upon State anxiety (1977). According to Tobias (1979), anxiety (an affective state) can indirectly affect learning (a cognitively mediated process) in certain stages of learning: preprocessing, during processing, and right after processing just before output. However, Tobias noted that the most debilitating effect of anxiety occurs during preprocessing. This research found specific instructional methods that relieved anxiety at each stage. During preprocessing, these studies found that student anxiety was decreased by allowing students to reinstitute input through rewatching audio or video materials or by using branching to revisit gaps in the learning. During processing, these studies showed that reducing the difficulty level of questions, reducing the load
on memory by giving students access to prior instructional content, and ensuring the information was well organized all reduced anxiety in learners.

In recent years, gamification has received much attention as a way of reducing anxiety in learners. Several studies in just the last 10 years have shown that gamifying learning can increase learners’ enjoyment and engagement as well as improve student attitude and motivation. Studies from 2016 also found that games engage higher-order cognitive skills (Brady & DeVitt, 2016), though a study done by Giannaokos showed they do not necessarily lead to knowledge acquisition (2013). Prensky and McGonigal’s stated that digital, game-based learning can increase student’s self-efficacy, optimism, motivation, performance and improve growth mindset (McGonigal, 2011; Prensky, 2001).

In 2001, Ashcraft & Kirk found that learners with high math anxiety have less available working memory, as some of the learner’s working memory is taken up by the anxiety rather than the material at hand. This is especially pronounced when learners are working with computations. Therefore, developing instruction that relieves learner anxiety is essential.

Cognitive Load Theory (CLT) states that only a certain amount of information can be held in one’s working memory at any given time. To maximize learning, instructional methods should be chosen that do not place an extraneous load on the working memory (Sweller & Chandler, 1991). Mayer’s Cognitive Theory of Multimedia Learning (CTML) states that certain multimedia principles can offer ways to reduce extraneous load by removing distracting or irrelevant material (Coherence, Signaling, Redundancy, Spatial and Temporal Contiguity principles), manage intrinsic load by chunking information and defining concepts early (Segmenting, Pretraining, and Modality principles), and using scaffolding and pacing to foster generative processing (Multimedia, Personalization, Voice, and Image principles) (Mayer, 2021).

Though these studies have shown that adding gamification elements to a learning environment can decrease anxiety for students, and Mayer’s Multimedia Principles have been shown to reduce extraneous load, manage intrinsic load, and foster generative processing, few studies have been conducted for applying multimedia principles in an online setting to reduce anxiety.

**Objectives**

There were several goals in redesigning the online statistics course. First, to gamify the course and apply multimedia principles to reduce students’ State anxiety and increase interest in the course. Second, to create an exemplar course for instructional design students that modeled Quality Matters standards and best design practices. Third, to use more of the tools within the Moodle LMS, automate the grading of assignments, and make the course more interactive using H5P.

**Gamification**

Specific game elements were added to the redesigned course. Statistics held some similar foundations as the martial arts which led to the Stats Kwon Do theme. For example, the balanced held by martial artists connects to measures of central tendency. A martial artist’s ability to know their reach relates to measures of variability, etc. Levels, another game element, was added by
way of earned martial arts belts of different colors (Figure 1). A story was added using a narrative that led students through Quests (Modules), Missions (Assignments), earning Power Ups (calculation tools), and culminating in Boss Fights (demonstrating learning via exams). Additionally, Multiple Attempts at viewing and practicing the content, and Goals and Progress Markers (Figure 2) in the form of a map which fills as the student progresses (Peters & Cornetti, 2020). The choice was made to not use the game element of Winning or using a Leaderboard to ensure students focused on playing and learning rather than on competing with one another.

**Figure 1**
*Red Belt Level Animation*

Note: Animation of martial artist performing for a red belt level.

**Figure 2**
*Quest 2 Progress Marker*

Note: The forest curve which functions as a map on which the forest animals appear while progressing through the course.
Multimedia Principles

Several multimedia principles were used to model best instructional design practices and to attempt to reduce anxiety in students. To reduce extraneous load, the principles of Coherence, Spatial and Temporal Contiguity, Signaling, and Redundancy were incorporated in all multimedia. To manage essential processing, Segmenting, and Modality were applied as well. To foster generative processing, the Voice and Personalization multimedia principles were used in the videos, and the use of Generative Activities was applied in the form of multiple examples and activities following each 3 to 5-minute video.

Research Design

The overarching question guiding the research was “Can using gamification and multimedia design principles reduce state anxiety in an online statistics course?” The research used qualitative data gathered from two groups of graduate students in an online statistics course over the course of its two first semesters undergoing the redesign process.

The first group consisted of 31 students enrolled in the initial redesign of the Stats Kwon Do course, and the second group consisted of 10 students in the second semester of the continued redesign of the Stats Kwon Do course. At the end of each chapter of the course, students were asked to provide feedback concerning a) statistics material that was still unclear, b) technology issues they encountered, and c) what they liked or disliked about the course. The student feedback served as data for a) improving instruction, b) improving the online interface, and c) analyzing students’ affective domain of learning. Feedback concerning unclear statistics material was used as formative evaluation by the instructional designer for improvements in future semesters, as well as providing the instructor with the opportunity to directly address the confusion with the student and/or review the content the next week in the instruction. Feedback concerning technology issues encountered offered the instructional designer/instructor opportunity to troubleshoot technical issues early, consider improvements for future semesters, and mitigate continued disruptions. Lastly, feedback concerning what students liked about the course offered qualitative data on students’ anxiety level with a relationship to what caused or relieved the anxiety within the course.

To help improve the instruction, student weekly feedback was collected in Moodle, transferred to a spreadsheet, and color-coded so that, as any comment was repeated by a student in a given week, it received darker shading (Figure 3). Thus, the more students noted the same issue, the darker the comment area would appear on the spreadsheet. This heatmap spreadsheet provided the instructor a visual cue as to where the most commonly noted problem or praise was reported during the week, which would guide either immediate or future improvements. The spreadsheet was also used to brainstorm possible solutions to issues students noted within the course in their comments.

Figure 3
Week 1, Semester 1 Heatmap of Student Feedback
Note: Student feedback for Week 1 of semester 1 with darker color noting more frequent mentions of a type of comment in the first column, possible solutions for the issues named in the comments in the second column, and possible ways to incorporate H5P for solving the issue.

The comments were also gathered in a Google document and categorized by code. The coded categories included General Questions (statistic questions, general course questions, and general comments), Technology Questions, Ideas for Improvements, Anxiety Reducers (comments including things students “enjoyed”, “loved”, or were “helped by”) and Anxiety Producers (comments including things that “worried”, “stressed”, “concerned” students).

To gather feedback on what specifically helped or increased anxiety within the course, the last two categories were further broken down into Anxiety Reducers and Anxiety Producers and coded. The coded subcategories for Anxiety Reducers were Gamification (comments noting game aspects of the course), General Teaching Comments (non-specific comments reference to the whole course) Visual elements (Video lesson, visual handouts), Segmenting (chunking of the lesson), and Mastery Practice (multiple examples, practices, attempts, and repeated video viewing). The coded subcategories for Anxiety Producers were Statistics (previously held anxiety of statistics), Teaching (missing or confusing instructions or course organization), and Textbook (textbook-related anxiety, vocabulary in the textbook).
Findings

In the first semester, a total of 1176 feedback comments were collected and coded. In the second semester, after trivial comments were removed, another 107 comments were collected and coded for a total of 1283 comments related to the course content.

Examination of the subcategory of Anxiety Reducer comments for the first semester, found the majority of comments (78%) cited the lesson videos and handouts as the source of their improved anxiety about the statistics course, followed by general teaching practices in the course (38%), opportunities to practice (26%), segmenting (19%), and gamification (9%) (Figure 4).

Figure 4
First Semester Anxiety Reducers

![First Semester Anxiety Reducers](image)

Note: Number of comments made about reduced anxiety referencing gamification (A+G), non-specific references to the course (A+T), video lesson and visuals (A+V), use of segmenting the learning (A+S), and ability to practice or view learning materials multiple times (A+P) in the first semester.

In the second semester, the majority of comments again cited the lesson videos and handouts as the source of improved anxiety (51%), with non-specific teaching practices following at 21%. Segmenting was cited in 12% of comments, followed by 11% for opportunities to practice, and 5% cited specific gamification items (Figure 5).
**Figure 5**  
*Second Semester Anxiety Reducers*

Note: Number of comments made about reduced anxiety referencing gamification (A+G), non-specific references to the course (A+T), video lesson and visuals (A+V), use of segmenting the learning (A+S), and ability to practice or view learning materials multiple times (A+P) in the second semester.

Most references made to feeling anxious were made in the first and second weeks of the first semester (Figure 6) and only increased in the 10th week when students were required to use text objects instead of videos for learning about hypothesis testing.

**Figure 6**  
*First Semester Anxiety Comments Comparison*

Note: Comparison of comments citing Anxiety Reducers and Anxiety Producers in the first semester.
Similarly, in the second semester, comments about feeling anxious were very common in the first several weeks but dropped or disappeared in the weeks following (Figure 7). Some anxiety again resurfaced in week 9 when hypothesis testing was again the topic.

**Figure 7**

**Second Semester Anxiety Comments Comparison**

Note: Comparison of comments citing Anxiety Reducers and Anxiety Producers in the second semester.

**Gamification Effect on Anxiety**

The use of gamification seems to have reduced student’s initial anxiety about the course. Many of the student comments reflected this effect. Some references included:

“Wahoo! I'm a yellow belt! The videos are super incredibly helpful. I am feeling even more confident with statistics. I am hopeful for this semester.”

“Statistics is an intimidating topic for me, but you have started the semester on a lighthearted note with "Stats Kwon Do." I actually almost look forward to the boss fights haha!”

“Enjoying the course so far. I find it well executed and fun. Very much enjoy the Stats qwan do approach gives a bit of levity to what is a pretty intimidating discipline.”

**Effects of Multimedia Principles on Anxiety**

Throughout the course of both semesters, student feedback sighted general and specific references to multimedia principles (Clark & Mayer, 2016) implemented within the course that
lowered their anxiety. In particular, the use of chunking or segmenting the instructional videos and materials student found helpful. Some feedback references include:

“"It's really nice to have the video recordings and the handouts, and the lessons broken up into pieces like this so it's not overwhelming."

“I must admit that I am finding this course to be much more manageable than I had initially thought it might be. I tend to struggle with any type of math, but am finding that the way the class is designed and broken up makes it very doable and less intimidating. I really appreciate all the examples and step-by-step videos for each topic. I like having the visual and various options to see the problems done multiple times. Thank you for making this class less scary! “

“I have been stressed out about taking this course. Math and I do not typically get along very well. I will say that just going through chapter one, I am feeling a bit calmer about the class. I like how you are breaking each item down, one by one and step by step. I love the handouts, and print them to take notes on while watching your videos.”

While one of students’ highest number of comments was the use of video lessons and visuals, all of which had incorporated one more of Mayer’s Multimedia Principles, it is not clear which particular principles relieved anxiety, but only that the application of one or more of them did seem to relieve anxiety. Further study is needed to break down which multimedia principles provide the most relief.

Conclusion

In the results of this study offer several patterns that can be seen in both semesters. First is the initial spike of comments about anxiety followed by a steady decline of anxious comments the rest of the semester. In the first weeks of the course in both semesters, students made many comments about feeling anxious including, “I'm quite fearful of statistics” and “I have struggled with math my entire life. This course is the one that I am afraid of taking and dealing with the most in my program.” Juxtaposed to this is the additional comments about game elements in the course by week 2 or 3 that show relieved anxiety and even confidence: “Wahoo! I'm a yellow belt! The videos are super incredibly helpful. I am feeling even more confident with statistics. I am hopeful for this semester” and “Very much enjoy the Stats kwon do approach gives a bit of levity to what is a pretty intimidating discipline.”

However, by the end of the course in both semesters there were very few comments about the game elements. By the time students were at the end of the course, they may have grown accustomed to the game elements as a natural part of the course. Nevertheless, the gamification did seem to relieve their initial anxiety upon entering the course. This initial relief of statistical anxiety may have allowed the students to begin the course without too many negative effects of anxiety, until they were into the flow of the course and had established a less negative view of the course material.

The second pattern observed is the high volume of student comments regarding specific course components based on multimedia principles which reduced the student’s anxiety. In both semesters, most of the comments pointed to the segmenting of the videos followed by examples and activities which fostered generative processing as a cause for reduction of students’ anxiety.
(short lectures and successful practice). Additionally, the ability to review and practice the videos and activities improved student confidence and reduced their anxiety. Therefore, it would seem that these multimedia principles did play a role in reducing student anxiety. Further study is needed to confirm which, if any, of the other multimedia principles contributed to the reduction of anxiety.

As this course continues to be improved, more H5P practice and practice blocks will be added for additional practice and mastery of concepts. Sets of these practice activities and examples may be created for specific fields of study to better engage groups of students attending the course by cohort. Question banks will continue to be added or enlarged for better randomization and variety of questions, and branching may be used to better remediate learners. Moodle tools like Books may be used to reduce the scrolling currently required for students, and a mission or task list for each quest will be made added for students to gauge their progress through a module. While the course seems to be actively reducing some anxiety in learners, the goal is to continue this trend and increase student confidence in wielding statistics.
References


