Simulation & Gaming
2017, Vol. 48(6) 832–854

DOI: 10.1177/1046878117731888
journals.sagepub.com/home/sag
SAGE

Gamified Modules for an Introductory Statistics Course and Their Impact on Attitudes and Learning

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Abstract

Background. The theory of gamified learning (Landers, 2014) posits that **gamified approaches** positively impact students' attitudes, and in turn this change in attitudes impacts learning; however, research is needed to examine the role of attitude change in **gamified approaches** (Seaborn & Fels, 2014). A strong negative relationship between students' attitudes towards statistics and their performance in statistics has been well documented. The need to help students have positive attitudes towards **statistics**, and therefore be more likely to achieve in the course, makes using **gamified learning**, which targets attitudes, an ideal domain to test the effects of gamification on attitudes.

Methods. The aim in this quasi-experimental study was to examine the ability of gamified modules in a statistics course to have positive impacts on learning and attitudes towards statistics. Students in the experimental group were compared to previous cohorts completing the same course, but without the gamified exercises as well as published results from a large cohort of comparable students.

Results. The attitudes of **cognitive competence**, affect, value and perceived difficulty were all positively impacted after completing the gamified exercises. The experimental group also had large effects of test performance one semester after completing the course.

Conclusion. In line with the theory of gamified learning, these findings suggested that the gamified modules were successful in shifting students' attitudes in a positive direction and subsequently increasing performance. Future studies

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should introduce randomization between students and examine the specific pathways between attitudes and performance.

Keywords
attitudes towards statistics, gamification, improving classroom teaching, pedagogical issues, post-secondary education, statistics education, teaching/learning strategies

There is an ongoing discussion in the literature regarding the effectiveness of using games in education, the terminology for such approaches (e.g., serious games, simulation, gamification, computer assisted instruction), the definitions of these terms as well as the overlap, and uniqueness of the approaches (Becker, 2005; Deterding, 2011; Landers, 2014; Seaborn & Fels, 2014). Researchers have also emphasized different elements of games as the most important for learning. For example, Gee (2003) emphasized the importance of games to motivate and engage, and create a learning environment for problem solving (Gee, 2009). Others have emphasized the importance of games to create learning by doing (Kapp, 2013; Merrill, 2009; Pannese & Carlesi, 2007; Vogel et al., 2006), and creating transferable mental models (Huang & Johnson, 2008). Some have argued that games should have built in goals (Becker, 2005) or be bound by rules with identified objectives that are achieved through problem solving and trial and error (Huang & Johnson, 2008). A newer conception in game research is gamification, an approach that adapts game elements and seeks to moderate learning by increasing motivation and attitudes (Deterding, 2011; Landers, 2014; Seaborn & Fels, 2014)

In this study, I worked from the most current theory of gamified learning (Landers, 2014) and the guidelines of Bedwell, Pavlas, Heyne, Lazzara, and Salas (2012) when defining the use of gamification in education. Although the focus of this study was to examine the impact of gamification, I define and summarize literature pertaining to both games in general and gamification given that gamification borrows elements of games and the literature on gamification is sparse (see Section 1.2). First, I define gamification and serious games, contrast them with other pedagogies, and describe the theory of gamified learning. Second, I provide a summary of the literature on the effectiveness of gamification in education. Finally, I present gamified modules created for a statistics course and the results of a study on the impact of those modules on student attitudes and learning. The overarching goal of this study was to fill the gap in the literature examining the effect of gamification on attitudes, a moderating variable argued to be essential in gamification's effects on learning.

Defining Games and Gamification

Games have a long history of being used for educational purposes. For example, games were used as early as the 18th century in training soldiers for battle (Egenfleldt-Nielsen, 2005). Even when games are created to be entertaining, one is still learning by mastering the rules and skills within the game. Games in the educational setting can be entertaining, but this is not typically their primary aim. When used in the educational setting games retract from the typical focus of entertainment and instead seek to increase learning (Susi, Johannesson, & Backlund, 2007). Educational games share elements with active learning, problem-based learning, scenario learning, role-play learning, independent learning and even simulations, which are often grouped or compared with games. They are active, can replicate real life situations and ask students to solve real life problems (Gee, 2003, 2009; Huang & Johnson, 2008; Kapp, 2013; Merrill, 2009; Pannese & Carlesi, 2007; Vogel et al., 2006); however, there are unique characteristics to games. Games are interactive, and bound by rules and constraints through which the player seeks to meet a specific objective or goal; games include challenges and can be competitive and provide feedback to the player (Becker, 2005; Deterding, 2011; Landers, 2014; Seaborn & Fels, 2014). Gamification, which is used in this study, is specific in that it borrows a number of these elements of games, but not necessarily all of them, to increase engagement in a non-game context (Deterding, 2011; Kapp, 2013; Landers, 2014; Seaborn & Fels, 2014).

Gamification is the adaptation of game elements with the goal of influencing behaviors and motivational or attitudinal constructs that mediate or moderate learning (Deterding, 2011; Landers, 2014; Seaborn & Fels, 2014). Moderation occurs when constructs increase the effectiveness of instructional content (Landers, 2014). For example, when instruction creates positive attitudes in students, and this in turn increases their engagement and subsequent learning, the construct(s) in the instruction that cause the increases in attitudes would be considered moderator(s). A mediator would include a behavior that by itself increases learning (Landers, 2014), such as having students use practice problems to increase recall, a methods known to directly increase learning. The use of moderators, such as positive impacts on attitudes, differentiates gamification from serious games where serious games are more focused on direct instructional content delivered through a game design to lead to learning. Although behavioral and attitudinal changes may occur as a result of using a serious game, this is not the primary goal of serious games; serious games seek to directly impact learning whereas gamification seeks to directly influence attitudes, which then moderates learning (Deterding, 2011; Landers, 2014; Seaborn & Fels, 2014).

Theory of Gamified Learning

Landers (2014) provided a theory of gamified learning that models the relationship between instructional content, game characteristics, behavior and attitudinal changes, and learning outcomes as they apply to gamification and serious games. I focus here on the application of the theory to gamification. Landers (2014) posited five paths within this theory. First, instructional content must already be effective. This implies that by adding game elements to ineffective instruction will not lead to improved learning. Second, the behaviors or attitudes believed to be encouraged by the instructional content or game characteristics must also have rational for affecting learning. For example, increased self-efficacy has been shown to be positively related to learning. As such, instructional content and game characteristics that improve self-efficacy would be appropriate according to the theoretical model. Third, game characteristics that are chosen should be known to influence the changes in behaviors and attitudes that are known to affect learning. The fourth and fifth paths deal with the moderation and mediation of learning. Either one or both can exist in gamification. Moderation exists when game characteristics are thought to influence learning by improving the effect of instructional content on learning. The instructional content must already be effective on its own therefore the game characteristics serve the role of enhancing this effect on learning. The game characteristics are effective to this end by encouraging behaviors and attitudes that maximize the instructional content. Mediation occurs when the game characteristics lead to a behavior or attitude that affects learning directly without contingence on the instructional content.

The gamification literature is sparse when it comes to reporting comparison studies that utilize methodology to control for or examine the differences in the effect of gamified curriculum (Seaborn & Fels, 2014). Researchers have called for studies that use such methodology to isolate specific elements of gamification to allow for a better understanding of how these elements play a larger role in impacting student learning (Landers, 2014; Seaborn & Fels, 2014). One such element is student attitudes. In the theory of gamified learning, attitudes are posited as a driving force that allows gamification to have positive impacts on learning (Landers, 2014). The gamified elements are said to create positive attitudes and these attitudes lead to behavior that instigates positive effects on learning. In this study, I collected data that focuses on the impact of gamification on attitudes. This allowed for an analysis of this isolated mechanism, attitudinal change when utilizing gamification that is argued to take place in gamification. It is important to understand whether these positive attitudinal changes exist as they are beneficial to students not only by increasing behaviors that improve learning in one course but are also paramount to students persisting in studying a subject (Eccles et al., 1983; Eccles & Wigfield, 2002). For example, in the math and science domains this is particularly important, as student retention is at an all time low (National Science Foundation, 2016). Students with more positive attitudes about math and science are more likely to take more related courses and obtain a degree in a related area (Eccles & Wigfield, 2002). This is true not only for students who are originally interested in math and science, but also students who have received interventions to develop positive attitudes towards the subjects (Yeager et al., 2016). If gamification is effective in having a positive impact on students' attitudes, subsequent benefits include positive impacts on learning as well as persistence in studying a given subject.

Effectiveness of Simulations, Serious Games and Gamification

The current study focused on gamification, which borrowed elements from games. Reviews on the effectiveness of simulations, computer based games and serious games used in education have shown positive effects on a number of variables. The effects have included better retention rates among students (Randel, Morris, Wetzel, & Whitehill, 1992), higher cognitive gain outcomes (Z = 6.05; Sitzman, 2011), and increases in procedural knowledge (*d* = .37), declarative knowledge (*d* = .28; Vogel et al., 2006) as well as retention of knowledge (*d* = .36; Wouters, van Nimwegen, van Ostendorp, & van der Spek, 2013).

Many games are computer based, but not all. Role playing games, for example, can be formatted without the use of computers. Non-computerized educational games, such as role playing games, have also been found to have positive effects on students. Students have reported that role-playing games are more stimulating than regular classroom formats, allow for more classroom engagement and help with understanding the course material (van der Meulen Rodgers, 1996). Experimental studies have shown that role-playing games have positive effects on problem solving and interacting with peers (McClure et al., 1978) as well as psychological outcomes such as self-esteem, empathy and beliefs about the malleability of ability, a strong predictor of academic success (Stroessner, Beckerman, & Whittaker, 2009).

Seaborn and Fels (2014) reviewed studies that specifically used gamification and concluded that of the 30 studies reviewed the results were generally positive. However, there were several limitations to the studies included in the Seaborn and Fels review. Few studies (11 out of 30) used a research design that allowed for comparison between the gamified condition and a control. Of those that did such comparative studies, 73% did in fact report positive results. Noted by Seaborn and Fels (2014) was that more comparative designs are needed to accumulate a larger body of literature on the effectiveness of gamification. Comparison studies allow researchers to disentangle the effects of gamification from other variables. For example, whether the effects are due to gamification or simply the novelty of experiencing gamification rather than a typical class, or even if the presence of computers alone account for the differences in outcomes for students in gamified and non-gamified conditions.

Another concern Seaborn and Fels' (2014) raised in their review was the lack of reference to theoretical constructs. The majority (87%) of studies failed to reference theory. This is of particular concern given that both the behavioral and attitudinal constructs encouraged by game characteristics are said to be causal to increases in learning, either by mediation or moderation. Future research is needed that specifically outlines how the game elements used in gamification are thought to be impacting behavioral and attitudinal constructs and these should then be empirically measured. Such studies would allow support for and potentially expand the gamified theory of learning in explaining how games impacts learning. The current study addressed the gap in the gamification literature by using comparative group data to determine whether gamification can impact attitudes, a potential mediator or moderate when learning.

Attitudinal Mediators and Moderators

The reviews to date on games and gamification (Seaborn & Fels, 2014; Sitzmann, 2011; Vogel et al., 2006) have begun to provide data that supports the theory the gamification by highlighting attitudinal and behavioral moderating or mediating variables. For example, in their meta-analysis, Vogel et al. (2006) reported more positive attitudes among students in game based conditions compared to control conditions

(*Z* = 13.74) and this exceeded the effect games had on learning overall (*Z* = 6.05). In Sitzmann's (2011) review, although games had an effect on learning (*d*s ≤ .37), its effect was much larger on self-efficacy (*d* = .53). Studies using gamified approaches have found improvements on enjoyment (Fernandes et al., 2012; Li, Grossman, & Fitzmaurice, 2012), engagement (Denny, 2013; Li et al., 2012; Passos, Medeiros, Neto, & Clua, 2011; Snyder & Hartig, 2013), motivation (Domínguez et al., 2013; Goehle, 2013) and appreciation of outcomes (Fernandes et al., 2012). The connection between games or gamification and these attitudes is helpful in determining the mechanisms that allow games to increase learning and can be useful to game designers when considering how to account for moderators or mediators of games and gamification. These findings are not surprising given that several theories on more entertainment games have empirical support that has shown games and gamification can increase engagement and motivation (Ju & Wagner, 1997; Kafai, 2001; Rieber, 1996).

Using Game Elements in a Statistics Course

The positive impact of gamification on attitudes makes it an ideal pedagogy for statistics courses where negative attitudes towards statistics can hinder achievement (Emmioğlu & Capa-Aydin, 2012; Ramirez, Schau, & Emmioğlu, 2012). For example, of the 17 studies on statistics attitudes and academic performance reviewed by Ramirez et al. (2012), 15 demonstrated a relationship between attitudes and academic performance such that positive attitudes led to higher academic performance and negative attitudes led to lower academic performance. Meta-analysis results have since confirmed this (Emmioğlu & Capa-Aydin, 2012). Academic performance has been defined in various ways in these studies, but nonetheless been related to attitudes. Students who have had negative attitudes towards statistics when starting a statistics course have had lower overall course grades (Cashin & Elmore, 2005) and lower test and quiz scores (Tempelaar, Schim van der Loeff, & Gijselaers, 2007).

The Model of Students' Attitudes Towards Statistics (SATS-M; Ramirez et al., 2012) provides a conceptual way for understanding how six attitudes lead to changes in academic performance. The SATS-M was derived from expectancy-value theory (Wigfield & Eccles, 2000) in which students' expectations of success and value towards an activity are considered to be strong predictors of engaging in and success with the activity. In the SATS-M this is translated into six attitudes: cognitive competence, affect, interest, value, perceived difficulty and effort. Cognitive competence, that is a student's perceived notion of their ability to perform well in a statistic course or self-efficacy, is argued to impact the student's subsequent affect, interest, value and perceived difficulty. These latter four attitudes are said to then dictate the level of effort put into the course and performance is a subsequent result of this. Support for this model has been provided in the literature (see Ramirez et al., 2012).

Given that the SATS-M is predictive of students' performance in statistics, when developing gamified material for use in statistics, it is important to ensure it will have a beneficial effect on the attitudes within the SATS-M. Past gamification research has demonstrated increases in self-efficacy that is students' perceptions of their cognitive ability to achieve an outcome. According to theories of self-efficacy, through gamification's interactive nature, students should increase effort, and be able to increase their efficacy by overcoming difficult tasks (Bandura, 1993; for a review see Sitzmann, 2011). This in turn leads to more positive affective states. These findings make gamification an ideal pedagogical approach for increasing attitudes towards statistics and in turn academic performance.

Various pedagogical approaches to adapting game elements to education have been employed to increase student learning in statistics by improving attitudes. For example, Carlson and Winquist (2011) demonstrated the ability to do this when using a classroom workbook activity designed with the intention to increase attitudes towards statistics. They found that the increase in attitudes led to increases in final exam scores. Game based pedagogies have also been shown to have direct positive impacts on learning in statistics. Basturk (2005) demonstrated benefits of using computer-assisted instruction (CAI) for one hour per week across a semester long introductory statistics course. Students attending the CAI lab had significantly higher grades on both the midterm and final exam compared to the control group. Also beneficial to learning statistics have been approaches that allow students to simulate real-life activities in statistics (Lawson, Schwiers, Doellman, Grady, & Kelnhofer, 2003; Schoenfelder, Olson, Bell, & Tom, 2007; Sterling & Gray, 1991; Wiberg, 2009).

Methods

The purpose of this quasi-experimental study was to examine the ability of gamified modules in a statistics course to have positive impacts on learning and attitudes towards statistics. I hypothesized that the gamification modules would lead to more positive attitudes and higher learning gains when compared to students who completed the course without the gamified modules and students in other published studies where attitudes have been measured throughout a course where gamification has not been used. Based on previous gamification research, I expected the effect on learning to be small to moderate ($d = .30\text{-}.50$) and the effect on attitudes to be larger ($d > .50$); however, the literature on attitudes and learning in statistics outside of game and gamification research has shown more modest effects, and as such, this study provided early evidence as to the size of the effect gamification can have on attitudes specifically in the statistics domain. This study also sought to provide evidence of effectiveness that would justify larger scaled studies that could systematically test the moderating and/or mediation role of attitudes.

Participants

The participants in this study were a convenience sample of undergraduate students enrolled in a statistic course statistics course, which was of particular interest for the study. A subset of the convenience sample constituted the experimental group and included students completing either a two-semester sequence in introductory statistics or research methods course offered through their psychology department ($n = 24$). Both courses covered the introductory statistics material that was used in the gamified modules. Students were in their second (25.00%), third (20.83%) or fourth year (54.16%). A majority of students were female (87.50%) and 54.16% reported their ethnicity as Caucasian followed by 37.50% reporting African American/Black. The average age of students was $M = 20.91(2.79)$. During the first semester of the course sequence, students engaged in the gamified modules. The second semester allowed students to continue to build on their previous work, but did not include the gamification modules.

Data from the experimental group were compared to data from two separate comparison groups. First, academic performance variables were compared with data from two cohorts of students who completed the statistics course sequence in the prior two years. The comparison group completed the same statistics course as the experimental group but without the gamified modules. The comparison and experimental groups had the same instructor, met similar day and time, and followed a fall-spring semester sequence. The students in the comparison group were similar in terms of gender and age [90.62% female; age $M = 20.31(1.28)$], but slightly fewer identified as African American and included a higher concentration of sophomores and juniors (58.82% Caucasian; 28.12% African American; 53.12% sophomore; 46.87% junior year).

Permission was obtained from the Institutional Review Board at the author's institution to collect survey data as well as academic record data such as students' class attendance, assignment and exam scores, and final grades. Students in both groups were informed on the consent form that collection of this data would allow the instructor to examine factors related to learning statistics. No other details were provided that would have lead the students to believe that their course would involve a strategy that had the chance of improving their experience, therefore it is unlikely that their participation in the study caused them to be more attentive during the activities. If a student had chosen not to consent to the study, this would have constituted their academic data being excluded from the final database, but would not have affected their attendance and activities in course.

Due to time constraints of the professor when instructing the students, attitude data was collected only from the experimental group. Rather than rely on pre-post data from only the experimental group, I chose to compare changes in the experimental group's attitudes to the most current published data from a US sample of statistics students (n = 342; Cashin & Elmore, 2005) where attitudes were measured at the beginning and end of the course. Comparing the experimental group to a comparison group increased the rigor of the study such that pre-post differences could be examined against a group that had not received gamification and therefore provided a level of control. Having a comparison group for attitudes changes was of particular importance for the argument that attitude changes are the mechanism by which learning improves in gamification.

The national comparison group differed by including both undergraduate and graduate students as well as other social science students (sociology, social work), and biology and nursing students, but was the most current publication that reported pre-post attitudes with enough data available to calculate effect sizes. Data from the study demonstrated that the Survey of Attitudes Towards Statistics is a reliable ($\alpha s \geq .74$) and valid measurement tool explaining statistics course achievement significantly more so than students' demographics alone. The study demonstrated a small change in attitudes after taking a statistics course (ds ≤ .19) and that pre-course attitudes, as well as demographics, predicted course outcomes.

Materials and Procedure

Attitudes towards statistics. Students in the experimental group completed the Survey of Attitudes Towards Statistics (SATS-36; Schau, Stevens, Dauphinee, & Del Vecchio, 1995) on the first and second to last class meeting, which allowed for pre-post comparisons. The SATS-36 contained thirty-six items rated on a 7-point Likert scale that make up six subscales: *Affect* evaluated the student's general attitude toward statistics. *Cognitive competence* evaluated students' perceptions of their ability to achieve in a statistics course. *Value* evaluated the attitude of how valued statistics are in the world. *Difficulty* evaluated the student's attitude regarding how difficult statistics is in practice. *Interest* evaluated student's interest in statistics. *Effort* evaluated student's effort put towards learning statistics. In this study, with the exception of the difficulty scale (α = .51), reliability estimates were high (α = .69-.91) and comparable to several studies that have demonstrated high reliability and validity (Hilton, Schau, & Olsen, 2004; Schau, 2003; Schau et al., 1995; Tempelaar et al., 2007).

Academic performance and learning. I collected data to assess both academic performance, which is commonly recorded in gamification research, and learning. Performance and learning have long been documented as separate constructs that do not necessarily correlate (Soderstrom & Bjork, 2015). As such, I examined the impact on both performance and learning measures. Data recorded for both the experimental and first comparison group included two performance measures: course grade and homework completion rate (% submitted). To measure learning, the Research Methods Skills Assessment (RMSA), a standard measure of knowledge and skills with statistics (Smith & Smith, in press), was given to all students at the end of the statistics course and then once more a full semester later. The RMSA was designed specifically for psychology students studying statistics. As such, it covered the applied nature of statistics outlined in the American Psychological Association's Guidelines for the Undergraduate Major (American Psychological Association, 2013) including ability to interpret descriptive statistics, confidence intervals, statistical vs. practical significance and choosing appropriate statistical tests for given scenarios. The RMSA has strong reported reliability, α = .75, and content validity (Smith & Smith, in press). Scores after completing a statistics course have averaged M = .54(.19) (Smith & Smith, in press). In this study, the reliability estimate for the scale was also strong (α = .91).

Educational intervention. While other studies have shown promise employing game elements in a statistics course, I used a gamified approach that includes modules using the components in Lander's (2015) theory of gamified learning and following Bedwell et al.'s (2012) taxonomies for gamification.

The instructional content came from an introductory statistics course for undergraduates studying psychology. The content covered introductory material and had a laboratory portion of the course where students produce descriptive statistic summaries in table and graph form, calculate standardized scores, percentiles, one-sample *t*-tests and effect sizes. The laboratory portion of the course was used for implementing the gamified elements in a supplemental fashion, an approach that has been shown to be more effective than transforming a full course into a game. The course had a high pass rate, which was taken as an indication of its effectiveness, a requirement in the theory of gamified learning. The characteristics of the game elements chosen were tested for their impact on the attitudinal constructs. Based on previous research (Sitzmann, 2011; Vogel et al., 2006) it was expected that interest and self-efficacy would be impacted by the gamification. Further, four other attitude constructs from the SATS-M, affect, value, perceived difficulty and planned effort, were also examined.

In previous semesters of this course, the instructor had students perform equivalent tasks during the laboratory portion of the classes; however, there was no intention or direct action taken to gamify the tasks. Rather, students were given a summary of instructions and left to complete the work on their own. They were able to ask questions when they arose, but the instructor was not intentional about giving trial/error feedback or encouraging interaction with peers. The students could complete tasks in any order without the need for instructor approval. The tasks were also not related to the scenario used in the gamified modules, but general unrelated examples that allowed students to complete equivalent tasks.

In the semester that gamification was used, the deliberate way in which these tasks were run was designed to meet both the definition and criteria of gamified. The game elements were chosen to apply empirically supported taxonomies and with the goal of increasing students attitudes towards the activities. The modules required students to complete a challenge embedded in a fictional scenario where feedback guided them through the tasks defined by clear goals and rules. In this way, the modules met the taxonomies that define common game elements (Bedwell et al., 2012) and employed them in a non-game environment. They met the definition of gamification such that they "intentional[ly] use[d] [of] game elements for a gameful experience of non-game tasks and contexts" (Seaborn & Fels, 2014, p. 17).

Three gamified modules were designed for students by applying specific game elements to a set of tasks carried out in the laboratory portion of classes. It is important to note that simply adding points, badges or other external rewards for performing a task does not lead to gamification and labeling such approaches as gamification has received criticism in the literature (Conway, 2014). Not only is the exclusive reliance on external rewards to gamify an activity potentially dangerous as rewards that are consistently external as opposed to internal can lead to decreases in learning (Eccles & Wigfield, 2002), but they also fail to help learners engage other characteristics that provide deep learning. Gamification requires that beyond external rewards, the player must immersive themselves into the activity, and have a sense of control in doing so that is guided by rules and embedded in fiction (Landers, 2014; Seaborn & Fels, 2014). In this study, I applied game elements such as "patterns, objects, principles, models, and methods directly inspired by games" (Seaborn & Fels, 2014, p. 17) to the information presented to students, and the activities they completed. The taxonomy provided by Bedwell et al. (2012) provided guidance to ensure that the activities were including elements deemed necessary when creating a gamified experiment. The taxonomy is a parsimonious list of categories that empirically condensed the broader categories suggested by Wilson et al. (2009). The nine categories are action language, assessment, conflict/challenge, control, environment, game fiction, human interaction, immersion, and rules/goals. I describe how the various game elements and taxonomies were used in each module in detail below. Table 1. provides a list of each gamified element in the modules with corresponding taxonomy. Module one used four of the nine taxonomies while modules two and three used eight of the nine taxonomies. The element of environment was not used in any of the modules. While the modules were completed in a computer-based classroom using the same software that is used in many real life admissions offices, other elements of the admissions office space were not mimicked.

There was no deliberate design put into place to encourage immersion; however, the use of computers may have instigated immersion to some extent. I used Jennett et al.'s (2008) definition of immersion as an experience during which the participant has a lack of awareness of time and the real world and a sense of being in the actual task environment. Immersion is a concept that has overlap with other concepts commonly cited in the game literature including engagement and flow (see Nilsson, Nordahl, & Serafin, 2016), however clear distinctions of the concepts have been offered by many game researchers (Finneran & Zhang, 2005). Further, some researchers have shown that immersion is multidimensional ranging from engagement to total immersion, and only the later would include flow (see Cheng, She, & Annetta, 2015). I use the term immersion in this study to be in line with the terminology used in the taxonomy that was used when designing the curriculum as well as with Jennett et al.'s definition of immersion. While it would be advantageous for the players to have reached a state of flow, no particular design elements were implemented to encourage flow; however, engaging with the computer interface may have provided a means for such flow, or even lower levels of immersion. Computer interfaces cannot on their own induce a state of flow. Theories of flow, including empirically validated theories related to computer-mediated environments all posit that congruence between the difficulty and challenge of the task, loss of awareness of surroundings, and internal motivation for participating must be present for flow to be obtained (Finneran & Zhang, 2005). Therefore, computer interfaces cannot induce lower levels of immersion, but may be able to help to facilitate immersion and flow given that they can reduce distraction and provide a sense balance between difficulty and ability as players become familiar with the program in which they are interacting.

Module one. Module one had fewer game elements (4 of 9) than the others making it a weaker in terms of gamification; however, this module was necessary in building the foundation on which the well gamified modules two and three build. The first module provided a presentation on research of how student attitudes related to learning, specifically in statistics and framed the game fiction for the semester, that is their fictional

Table 1. Summary of Statistics Gamified Elements With Corresponding Taxonomy Category and Definition.

Game Taxonomy	Definition	Statistics Gamified Element
Action Language	The method and interface by which communication occurs between a player and the game itself.	Students use SPSS to answer questions embedded in each challenge.
Assessment	The method by which accomplishments and game progress are tracked.	The instructor provides individualized feedback during all modules. The feedback encourages trial and error. Moving to the next task is dependent on instructor approval.
Conflict/Challenge	The problems faced by players, including both the nature and difficulty of those problems.	Students answer a series of questions in each module that using the real-life analysis process.
Control	Degree to which players are able to alter the game, and the degree to which the game alters itself in response.	Students choose their variable of choice to use in subsequent analyses. Their choice dictates the analysis results, which in turn lead to the need for further choices regarding follow-up analyses.
Environment	The representation of the physical surroundings of the player.	Not applied in this curriculum.
Game fiction	The fictional game world and story.	In module 1 students are immersed into the game fiction used in modules 2 and 3. Students work under the fictional guise of a college recruiter who chooses candidates applying to college.
Human interaction	The degree to which players interact with other players in both space and time.	The instructor interacts with students to guide their progress. When appropriate, students are encouraged by the instructor to seek advice from other students who have successfully completed a task.
Immersion	The affective and perceptual experience of a game.	Computer interfaces allowed for facilitation of immersion.
Rules/Goals	Clearly defined rules, goals and information on progress toward those goals, provided to the player.	Each module has a series of tasks that must be completed to answer the overarching question(s) in that module. Students are given feedback on each task and cannot move forward without approval of the instructor.

Note. Game taxonomies are from Bedwell et al. (2012), and the definitions are from Landers (2015).

role as a graduate admissions counselor who must decide what students will be admitted to graduate school. The type of work done by admissions staff that process application data and generate criteria for admissions was discussed with students. This was important as the story of the admissions counselor was infused throughout the following modules as the students moved through tasks of varying levels of difficulty that would be conducted by an admissions office and increased in difficulty. In module one, students were shown data in graphical and table form from the dataset of "applicants" that they were to use. Students were then given a brief demonstration of how such graphs were created in SPSS and they were challenged with replicating these graphs and tables in SPSS from which they then answered a series of questions. This mimicked a basic level task that would be done on admissions data to summarize who is applying to the school. This module applied the taxonomies of assessment, conflict/challenge and rules/goals. The instructor provided assessment in the form of feedback as students move through each task. In this way, students had feedback on incremental progress. If an incorrect step was taken, trial and error was encouraged. When a step or task was completed correctly, students were then able to move to the next step or task listed on a handout given to students at the onset of the module. Throughout all modules, students were encouraged to work with peers to share successful strategies and compare findings and/or tips to help overcome difficulties; this was only limited if the student had not yet attempted a task independently first. The challenge was to replicate the results presented to the class and to then extract answers to questions from the graphs and tables generated. The rules and goals of the tasks included proceeding through the tasks in order, moving forward only when the instructor indicates to do so and to successfully replicate the graphs and tables and answer the questions from that data.

Module two. In module two, students were introduced to a new challenge that mimicked a next stage when determining admissions. The challenge was to choose 50 students from the data who should be accepted into college; however, there was a stipulation that a portion of the students will be enrolled in the "PsycUp" program, a program for those with low test scores in statistics but considered to have high potential for achievement in graduate school due to their scores on an attitude inventory. The students had to first choose one attitude or behavioral variable (e.g., interest, value, effort) that they believed will indicate high potential for achievement then proceed in the selection process using *z*-scores to identify various groups of students including the top and bottom 30 percentiles, the four quartiles and a 95% confidence interval. They then chose the students to be admitted to college.

In this module, Bedwell et al.'s taxonomies of assessment, conflict/challenge, control, game fiction, human interaction and rules/goals wer applied. Again, the instructor provided assessment in the form of feedback incrementally throughout the steps of each task and student marked off their achieved steps on a checklist. The challenge was to choose the students best suited for graduate school. Students were informed that the sample they chose will be tested in the next module, and careful selection was important. Students had control over the attitude variable they chose as a selection criteria as well as the choice of cutoff scores for selection. The cutoff scores can be based on one of the following: confidence interval, 30^{th} percentile score or quartile score. Game fiction was introduced through the scenario of choosing students for graduate school. Human interaction was encouraged when students mad an error. The instructor encouraged them to problem solve with another student on possible ways to attempt to find a correct answer. For consistency, the rules/goals were structured in this module as they were in the first module.

Module three. The third module had students run one-sample *t*-tests with effect sizes to compare their selected sample of students to the overall averages for the whole student "population". For the purposes of these modules, the data provided was said to represent the whole population. Students had to compare their samples' average GPAs and attitude scores (both for the PsycUp program and general admission) to the population. They were then required to make a judgment as whether or not they believed the students chosen for general admission and for the PsycUp program did appear to have potential for success in graduate school. They used both hypothesis testing and effect sizes when defending their conclusions.

Assessment, in the form of instructor's incremental feedback was applied in the third module and students marked this achievement on a checklist given at the beginning of the module. The conflict/challenge was to defend with statistical evidence whether the students selected showed potential for graduate school, or whether the selection process was flawed. The game fiction was maintained by continuing the scenario of choosing students for graduate school. Human interaction was encouraged among students for brainstorming on how to correctly complete tasks. The rules/goals were consistent with modules one and two.

Analysis

Paired samples *t*-tests were used to compare pre-post attitude scores. The effect sizes observed for attitude changes in the current study were compared to effect sizes observed in the national sample described in the "participants" section.

Independent samples *t*-tests compared academic performance and learning variables between the experimental group and the comparison group. These groups represented the two cohorts previously completing the same statistics course.

For all analyses, *t*-tests and two-tailed *p*-values were reported; however, in line with recommendation for analyzing data with the "new statistics" (Cumming, 2014), particular attention was paid to effect sizes and confidence intervals.

Results

Changes in Attitudes Towards Statistics

Means, confidence intervals and effects sizes for attitudes pre and post are reported in Table 2. A moderate change was observed for affect, $t(23) = -2.67$, $p = .014$, $d = .54$,

Table 2. Descriptive Statistics and Changes in Attitudes for the Experimental Group and Comparison Group.

	Experimental Group (n = 24)			Comparison Group 1 (n = 342; (Cashin & Elmore, 2005)
	Pre M [95% CI]	Post M [95% CI]	*d*	*d*
Attitudes				
Cognitive Competence	4.19 [3.66, 4.71]	4.54 [4.10, 4.99]	.37	.02
Affect	3.47 [2.89, 4.06]	4.06 [3.52, 4.60]	.54*	.19
Interest	4.63 [3.97, 5.29]	4.40 [3.77, 5.03]	−.16	n/a
Value	4.76 [4.41, 5.11]	4.92 [4.55, 5.29]	.22	−.11
Difficulty	3.07 [2.73, 3.40]	3.22 [2.81, 3.64]	.16	.11
Effort	5.89 [5.49, 6.29]	6.11 [5.71, 6.51]	.21	n/a

Note. Cashin and Elmore (2005) used a previous version of the SATS (SATS-28) that included only four scales: cognitive competence, affect, value and difficulty.
*$p < .05$

and competence, $t(23) = -1.85$, $p = .077$, $d = .37$. Smaller effects were found over time for the remaining attitudes: interest, $p = .428$, $d = .16$; difficulty, $p = .348$, $d = .19$; effort, $p = .323$, $d = .206$; and, value, $p = .292$, $d = .22$.

When compared to effect sizes for pre-post attitudes over the duration of a statistics course (Cashin & Elmore, 2005; see Table 2) the respective effect sizes observed in this study were much larger for affect, $d = .19$ vs. $d = .54$, competence, $d = .02$ vs. $d = .37$, value $d = -.11$ vs. $d = .22$, and difficulty, $d = .11$ vs. $d = .19$. Although Cashin and Elmore (2005) did not measure interest and effort due to using a previous version of the SATS, the effect size in the current study for interest ($d = .16$) and effort ($d = .21$) were comparable to that of the largest observed effect size in the comparison study ($d = .19$ for affect).

Academic Performance and Learning

Homework grades were higher for the experimental group, $t(54) = -2.15$, $p = .036$, $d = .58$, however course grades had little difference between groups, $p = .711$, $d = .10$ (see Table 3). When comparing scores on the RMSA, the comparison group had non-significant higher score at the end of the statistics course than the experimental group, $p = .13$, however this yielded a moderate effect size, $d = .41$. The reverse effect was found when comparing RMSA scores one semester later, such that the experimental group had significantly higher scores with a moderate effect size, $t(54) = -2.31$,

Table 3. Performance and Learning Outcomes for the Experimental and Comparison Group.

	End of Statistics Course			One Semester Post		
	Experimental Group (n = 32)	Comparison Group (n = 24)		Experimental Group (n = 32)	Comparison Group (n = 24)	
	M [95% CI]	M [95% CI]	*d*	M [95% CI]	M [95% CI]	*d*
Homework Grade	.86 [.82, .91]	.75 [.68, .83]	.58*	n/a	n/a	n/a
Course Grade	.81 [.74 .89]	.80 [.76, .84]	.10	n/a	n/a	n/a
RMSA	.49 [.37, .61]	.59 [.53, .65]	.41	.72 [.64, .81]	.60 [.55, .67]	.62*

Note. The comparison group consists of the previous two cohorts of students taking the same statistics course.
*$p < .05$

$p = .025$, $d = -.62$. One-sample *t*-tests compared both RMSA post scores for both groups to the overall score reported when validating the instrument, $M = .54$ (Smith & Smith, in press). The control group's scores approached significance and had a small effect at the end of the first semester, $p = .08$, $d = .31$, and the second semester, $p = .055$, $d = .35$. The experimental group's scores at the end of the first semester were not significantly different from the overall score ($M = .54$), $p = .42$, $d = .16$; however, the experimental group had a significantly higher score at the end of the second semester with a large effect size, $t(23) = 4.40$, $p < .001$, $d = .90$.

Discussion

Changes in Attitudes

The goal of this study was to examine the impact of a gamification on attitudes, which have been argued to be the driving force in improving learning when gamification is used. It was expected that completing the gamified modules would have a positive impact on attitudes and course grades as well as scores on a standard measure of skills. In this study, six attitudes represented in the SATS-M were measured both before and after engaging in the gamified modules. The SATS-M posits cognitive competence as a precursor to developing other positive attitudes towards statistics and higher academic performance in statistics. It is encouraging that after completing the modules cognitive competence increased and reached the effects sizes reported in the gamification literature, $d = .54$. The positive change in cognitive competence is consistent with past studies that have shown self-efficacy benefits from gamification. That is, after completing gamified activities, participants felt more competent in the domain in which the gamification took place.

The SATS-M posits that increases in cognitive competence leads to increases in affect, interest, value and difficulty. The observed increases in difficulty scores were a positive change that indicated that students found the subject less difficult. In this study, in addition to increases in cognitive competence, students also showed increases in three of the subsequently impacted attitudes of affect, value and perceived difficulty (d = .37, .22, and .16, respectively); however, students' interest in statistics shifted in an unexpected direction. There was a small decrease in interest, $d = -.11$. Interest has been argued to be an integral factor in learning (Renninger, 1992), making this decrease of some concern. On the other hand, other beneficial increases were observed with respect to cognitive competence, affect and value. Students' value increased two times in magnitude when compared to the small decrease in interest. Wigfield & Eccles (2000) have shown that high levels of value towards math are most important for continuing to study math in the future. With the exception of the change in interest, these results provided support for the SATS-M and particularly the positive impact of gamification on these attitudes.

The gamified modules used in this study were designed to transform typical laboratory activities in statistics courses to adhere to the theory of gamified learning. Through this approach, similar to other gamified approaches, positive impacts were observed on students' attitudes. When comparing the effect sizes related to attitude changes observed in this study to those in a comparison study that measured pre-post attitudes in a statistics course without gamification, the effects sizes here exceed those found in the comparison study. After using the gamified approach for the laboratory activities, students' cognitive competence, affect and value all increased. Students also perceived statistics to be less difficult after completing the gamified modules. In the comparison study, students' value towards statistics actually decreased over the duration of the course; however, in this study, value increased. As previously noted, value has been demonstrated to be a strong predictor of continued study in math. The findings in this study suggested that the use of gamification in a statistics course is one way to have a positive impact on value, among other attitudes, compared to a standard non-gamified curriculum.

Changes in Effort and Performance

The final attitude in the SATS-M that impacts performance is effort. There was a small increase in students' reported intended (pre) and actual (post) effort. This is consistent with the argument that the interactive nature of gamification increases effort. Consistent with this increase in effort was the higher homework completion rate among the experimental group (d = .58) indicating they were more engaged in the course outside of the gamified modules. With respect to performance, course grades differed little between the group (d = .10); however, when comparing learning using the RMSA scores, contrary to expected, the comparison group had a moderately higher score at the end of the first semester of the statistics course (d = .41); however, when completing the RMSA a semester later, the experimental group not only outperformed the comparison group

($d = .62$) but also had a large difference when compared to the sample used in developing the RMSA ($d = .90$). This is consistent with research on performance and learning that shows that high performance, such as course grade, is distinctive from learning and does not automatically transfer to learning. That is, students with low levels of performance can demonstrate high levels of learning later on, and vise versa (see Soderstrom & Bjork, 2015 for a review). I observed this phenomenon. The experimental group did not show high levels when measuring performance (i.e., course grade) but did exhibit high levels of learning (i.e., RMSA scores one semester later), and this pattern was only evident among the experimental group. This suggests that the gamification had a positive impact on learning.

Implications and Future Research

This study adds to the literature that utilizes a pre-post comparison design to investigate the impact of gamification on attitudes. After completing the gamified instruction, there was a positive impact on students' attitudes towards statistics and learning. This is of particular interest within the domain of statistics given the strong relationship documented between attitudes and learning. To increase attitudes and thereby learning, instructors should consider adding gamified elements to their existing statistics course curriculum. This study demonstrated how instructors could transform existing portions of their curriculum to adhere to gamified principles and observe effects established in the gamification literature. This can allow instructors to continue to use the same activities and resources, but apply them in a more effective manner. The ability to gamify standard course material in this way broadens the reach of gamification and their positive impacts.

This study was limited in that it only sampled a small group of students, and did not use randomized conditions. Future studies should also consider not only the effect of gamification on attitudes and learning, but also examine the impact of gamification to improve other barriers to learning in statistics such as anxiety (Chew & Dillon, 2014; Onwuegbuzie & Wilson, 2003). More specific attention can also be paid to what specific elements of the gamified instruction impact attitudes and the way in which this is directly or indirectly influencing learning. That is, does cognitive competence, value, interest, affect and difficulty directly impact learning or are they contingent upon the instructional content and gamified elements? Further, what gamified elements were the most effective? If the one or more of the gamified elements is removed, does the effectiveness change? Large samples of students would be needed this type of longitudinal analysis. More diverse samples could be utilized across multiple institutions. High school students interested in STEM (science, technology, engineering and mathematics) majors or graduate students pursuing a research based profession would also be important populations with whom to test gamification in statistics as they are often required to complete statistics courses. Students in other majors may also be required to take statistics as a general requirement and examining the impact with these populations is also needed. Other variables that may impact learning, such as GPA, taking statistics as part of your major, cohort characteristics and students' game preferences (e.g., "gamers" vs. "non-gamers") should be examined in future studies.

The use of a specific theoretical model related to attitudes towards statistics in this study allowed the data to illustrate specific attitude constructs that are and are not impacted by gamification. Future studies should be careful to measure constructs directly and compare them across various samples where various pedagogies, including gamification, are used. As noted by Huang, Johnson, and Han, (2013), research has clearly demonstrated increases in motivation as a result of gamified approaches, however we remain unclear about how this happens. Landers (2014) provided a theory for explaining this; but, experimental designs must be improved upon to implement promising gamification in way that systematic testing can be done (Seaborn & Fels, 2014).

Learning is the ultimate goal of gamification in education. Measuring learning can be problematic. Using academic performance as a measure of learning is important, but the skills students are learning should be distinguished from other factors that go into a course grade such as attendance, and even various elements of assignments that are not specifically related to statistics content knowledge (e.g., following formatting instructions, spelling and neatness). In this study, I found that course grades did not differ between those who had the gamified instruction compared to those who did not, but large differences existed on a standard measure of skills. Time is also an important element when measuring learning. Researchers should design their studies to examine effects over time rather than relying on one-time measurements taken closely after completing gamified curriculum.

Conclusion

Overall, this study provided early evidence effectiveness of a gamified approach that is structured using the theory of gamification on students' attitudes. Attitudes, an important factor related to learning statistics, were changed positively after having the gamified instruction and long-term knowledge gains resulted. Future studies should aim to include standard skill and learning measurements and expand this work to other important populations. In addition, particular attention should be paid to measuring specific theoretical constructs and designs employed to explore the mediating and moderating relationship between attitudes and learning when using gamification.

Acknowledgment

The author would like to thank Dr. Thomas Heinzen for his guidance and expertise as well as two anonymous reviewers for their comments on earlier versions of this manuscript.

Declaration of Conflicting Interest

The author declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The author received no financial support for the research, authorship, and/or publication of this article.

References

American Psychological Association. (2013). *APA guidelines for the undergraduate psychology major, version 2.0*. Washington, DC: Author. Retrieved from http://www.apa.org/ed/precollege/about/psymajor-guidelines.pdf

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist*. doi:10.1207/s15326985ep2802_3

Basturk, R. (2005). The effectiveness of computer-assisted instruction in teaching introductory statistics. *Educational Technology & Society*, *8*, 170-178. Retrieved from http://www.ifets.info/journals/8_2/16.pdf

Becker, K. (2005). How are games educational? Learning theories embodied in games. *Changing Views: Worlds in Play*, 1-6. Retrieved from http://www.digra.org/wp-content/uploads/digital-library/06278.23299.pdf

Bedwell, W. L., Pavlas, D., Heyne, K., Lazzara, E. H., & Salas, E. (2012). Toward a taxonomy linking game attributes to learning: An empirical study. *Simulation & Gaming*, *43*(6), 729-760. doi:10.1177/1046878112439444

Carlson, K., & Winquist, J. (2011). Evaluating an active learning approach to teaching introductory statistics: A classroom workbook approach. *Journal of Statistics Education*, *19*(1), 1-23. Retrieved from http://www.amstat.org/publications/jse/v19n1/carlson.pdf

Cashin, S. E., & Elmore, P. B. (2005). The Survey of Attitudes Toward Statistics Scale: A construct validity study. *Educational and Psychological Measurement*, *65*(3), 509-524. doi:10.1177/0013164404272488

Cheng, M. T., She, H. C., & Annetta, L. A. (2015). Game immersion experience: Its hierarchical structure and impact on game-based science learning. *Journal of Computer Assisted Learning*, *31*(3), 232-253. doi:10.1111/jcal.12066

Chew, P. K. H., & Dillon, D. B. (2014). Statistics anxiety update: Refining the construct and recommendations for a new research agenda. *Perspectives on Psychological Science*, *9*(2), 196-208. doi:10.1177/1745691613518077

Conway, S. (2014). Zombification?: Gamification, motivation, and the user. *Journal of Gaming and Virtual Worlds*, *6*(2), 129-141. doi:10.1386/jgvw.6.2.129_1

Cumming, G. (2014). The New Statistics: Why and how. *Psychological Science*, *25*(7), 7-29. doi:10.1177/0956797613504966

Denny, P. (2013). The effect of virtual achievements on student engagement. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems - CHI '13* (pp. 763-772). doi:10.1145/2470654.2470763

Deterding, S. (2011). Gamification: Toward a definition. In *CHI 2011 Gamification Workshop Proceedings* (pp. 12-15). doi:10.1145/2212877.2212883

Domínguez, A., Saenz-De-Navarrete, J., De-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J. J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers and Education*, *63*, 380-392. doi:10.1016/j.compedu.2012.12.020

Eccles, J. S., Adler, T., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motivation: Psychological and sociological approaches* (pp. 75-146). San Francisco, CA: Free man.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values and goals. *Annual Review of Psychology*, *53*, 109-132. doi:10.1146/annurev.psych.53.100901.135153

Egenfleldt-Nielsen, S. (2005). *Beyond edutaiment* (Doctoral disseration). Retrieved from http://education.ucf.edu/insttech/docs/egenfeldt.pdf

Emmioğlu, E., & Capa-Aydin, Y. (2012). Attitudes and achievement in statistics: A meta-analysis study. *Statistics Education Research Journal*, *11*(2), 95-102. Retrieved from https://iase-web.org/documents/SERJ/SERJ11(2)_Emmioglu.pdf

Fernandes, J., Duarte, D., Ribeiro, C., Farinha, C., Pereira, J. M., & Da Silva, M. M. (2012). IThink: A game-based approach towards improving collaboration and participation in requirement elicitation. *Procedia Computer Science*, *15*, 66-77. doi:10.1016/j.procs.2012.10.059

Finneran, C. M., & Zhang, P. (2005). Flow in computer-mediated environments: Promises and challenges. *Communications of the Association for Information Systems*, *15*(January), 82-101. Retrieved from http://aisel.aisnet.org/cais/vol15/iss1/4/

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment*, *1*(1), 20. New York: Palgrave Macmillian. doi:10.1145/950566.950595

Gee, J. P. (2009). Deep learning properties of good digital games: How far can they go? In *Theories and mechanisms: Serious games for learning* (pp. 63-80). doi:10.1016/j.cger.2011.07.001

Goehle, G. (2013). Gamification and web-based homework. *Primus*, *23*(3), 234-246. doi:10.1080/10511970.2012.736451

Hilton, S. C., Schau, C., & Olsen, J. A. (2004). Survey of attitudes toward statistics: Factor structure invariance by gender and by administration time. *Structural Equation Modeling*, *11*(1), 92-109. doi:10.1207/S15328007SEM1101_7

Huang, W. D., & Johnson, T. (2008). Instructional game design using cognitive load theory. In R. Ferdig (Ed.), *Handbook on research of effective electronic gaming in eduction* (pp. 1143-1165). Hershey, PA: Information Science Reference. doi:10.4018/978-1-59904-808-6.ch066

Huang, W. D., Johnson, T. E., & Han, S. H. C. (2013). Impact of online instructional game features on college students' perceived motivational support and cognitive investment: A structural equation modeling study. *Internet and Higher Education*, *17*(1), 58-68. doi:10.1016/j.iheduc.2012.11.004

Jennett, C., Cox, A. L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T., & Walton, A. (2008). Measuring and defining the experience of immersion in games. *International Journal of Human Computer Studies*, *66*(9), 641-661. doi:10.1016/j.ijhcs.2008.04.004

Ju, E., & Wagner, C. (1997). Personal computer adventure games: Their structure, principles, and applicability for training. *The Databse for Advances in Information Systems*, *28*(2), 78-92. doi:10.1145/264701.264707

Kafai, Y. B. (2001). The Educational Potential of Electronic Games: From Games – To – Teach to Games – To – Learn. *Playing by the Rules*, 1-6. Retrieved from http://culturalpolicy.uchicago.edu/papers/2001-video-games/kafai.html

Kapp, K. (2013). *The gamification of learning and instruction field book: Ideas into practice*. Hoboken, NJ: Wiley. Retrieved from http://www.wiley.com/WileyCDA/WileyTitle/productCd-111867443X.html

Landers, R. N. (2014). Developing a theory of gamified learning: Linking serious games and gamification of learning. *Simulation & Gaming*, *45*(6), 752-768. doi:10.1177/1046878114563660

Lawson, T. J., Schwiers, M., Doellman, M., Grady, G., & Kelnhofer, R. (2003). Enhancing students' ability to use statistical reasoning with everyday problems. *Teaching of Psychology*, *30*(2), 107-110. doi:10.1207/S15328023TOP3002_04

Li, W., Grossman, T., & Fitzmaurice, G. (2012). GamiCAD: A gamified tutorial system for first time AutoCAD users. In *UIST'12 - Proceedings of the 25th Annual ACM Symposium on User Interface Software and Technology* (pp. 103-112). doi:10.1145/2380116.2380131

McClure, L. F., Chinsky, J. M., Larcen, S. W., Audietus, S., Bakke, P., Brown, B., . . . Rutowski, K. (1978). Enhancing social problem-solving performance in an elementary school setting. *Journal of Educational Psychology*, *70*(4), 504-513. doi:10.1037/0022-0663.70.4.504

Merrill, M. D. (2009). First principles of instruction. In C. M. Reigeluth & A. Carr (Eds.), *Instructional design theories and models: Building a common knowledge base* (Vol. III). New York, NY: Routledge. doi:10.1007/BF02505024

National Science Foundation. (2016). *National Science Board Science and Engineering Indicators* (NSB-2016-1). Arlington, VA: National Science Foundation. doi:10.1002/ejoc.201200111

Nilsson, N. C., Nordahl, R., & Serafin, S. (2016). Immersion revisited: A review of existing definitions of immersion and their relation to different theories of presence. *Human Technology*, *12*(2), 108-134. doi:10.17011/ht/urn.201611174652

Onwuegbuzie, A. J., & Wilson, V. A. (2003). Statistics anxiety: Nature, etiology, antecedents, effects, and treatments–a comprehensive review of the literature. *Teaching in Higher Education*, *8*(2), 195-209. doi:10.1080/1356251032000052447

Pannese, L., & Carlesi, M. (2007). Games and learning come together to maximise effectiveness: The challenge of bridging the gap. *British Journal of Educational Technology*, *38*(3), 438-454. doi:10.1111/j.1467-8535.2007.00708.x

Passos, E. B., Medeiros, D. B., Neto, P. A. S., & Clua, E. W. G. (2011). Turning real-world software development into a game. In *Proceeding of SBGames* (pp. 1-8). doi:10.1109/SBGAMES.2011.32

Ramirez, C., Schau, C., & Emmioğlu, E. (2012). The importance of attitudes in statistics education. *Statistics Education Research Journal*, *11*(2), 57-71. Retrieved from https://iase-web.org/documents/SERJ/SERJ11(2)_Ramirez.pdf

Randel, J. M., Morris, B. A., Wetzel, C. D., & Whitehill, B. V. (1992). The effectiveness of games for educational purposes: A review of recent research. *Simulation & Gaming*, *23*(3), 261-276. doi:10.1177/1046878192233001

Renninger, K. A. (1992). Individual interest and development: Implications for theory and practice. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 361-395). Hillsdale, NJ: Erlbaum.

Rieber, L. P. (1996). Seriously considering play: Designing interactive learning environments on the blending of microworlds, simulations, and games. *Educational Technology Research and Development*, *44*(2), 43-58. doi:10.1007/BF02300540

Schau, C. (2003). Students' attitudes: The "other" important outcome in statistics education. In *Joint Statistical Meetings* (pp. 3987-3992). Alexandra, VA: American Statistical Association. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.144.6628&rep=rep1&type=pdf

Schau, C., Stevens, J., Dauphinee, T. L., & Del Vecchio, A. (1995). The development and validation of the Survey of Attitudes Toward Statistics. *Educational and Psychological Measurement*, *55*(5), 868-875. doi:10.1177/0013164495055005022

Schoenfelder, E., Olson, R., Bell, M., & Tom, K. (2007). Stop and smell the roses: An activity for teaching the central limit theorem. *Psychology Learning and Teaching*, *6*(2), 80-84. doi:10.2304/plat.2007.6.2.80

Seaborn, K., & Fels, D. I. (2014). Gamification in theory and action: A survey. *International Journal of Human Computer Studies*, *74*, 14-31. doi:10.1016/j.ijhcs.2014.09.006

Sitzmann, T. (2011). A meta-analytic examination of the instructional effectiveness of computer-based simulation games. *Personnel Psychology*, *64*(2), 489-528. doi:10.1111/j.1744-6570.2011.01190.x

Smith, T., & Smith, S. (in press). Reliability and validity of the research methods skills assessment. *International Journal of Teaching and Learning in Higher Education*, *30*(1). Retrieved from http://www.isetl.org/ijtlhe/forthcoming.cfm?v=30&i=1

Snyder, E., & Hartig, J. R. (2013). Gamification of board review: A residency curricular innovation. *Medical Education*, *47*(5), 524-525. doi:10.1111/medu.12190

Soderstrom, N. C., & Bjork, R. A. (2015). Learning versus performance: An integrative review. *Perspectives on Psychological Science*, *10*(2), 176-199. doi:10.1177/1745691615569000

Sterling, J., & Gray, M. W. (1991). The effect of simulation software on students' attitudes and understanding in introductory statistics. *Journal of Computers in Mathematics and Science Teaching*, 10(4), 51-56. Retrieved from https://eric.ed.gov/?id=EJ438302

Stroessner, S. J., Beckerman, L. S., & Whittaker, A. (2009). All the world's a stage? Consequences of a role-playing pedagogy on psychological factors and writing and rhetorical skill in college undergraduates. *Journal of Educational Psychology*, *101*(3), 605-620. doi:10.1037/a0015055

Susi, T., Johannesson, M., & Backlund, P. (2007). Serious games – An overview. *Elearning*, *73*(10), 28. doi:10.1.1.105.7828

Tempelaar, D., Schim van der Loeff, S., & Gijselaers, W. H. (2007). A structural equation model analyzing the relationship students' statistical reasoning abilities, their attitudes toward statistics, and learning approaches. *Statistics Education Research Journal*, *6*(2), 78-102. Retrieved from https://iase-web.org/documents/papers/icots7/2G3_TEMP.pdf

van der Meulen Rodgers, Y. (1996). A role-playing exercise for development and international economics courses. *Journal of Economic Education*, *27*, 217-223. doi:10.2307/1183292.

Vogel, J. J., Vogel, D. S., Cannon-Bowers, J., Bowers, C. A., Muse, K., & Wright, M. (2006). Computer gaming and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research*, *34*(3), 229-243. doi:10.2190/FLHV-K4WA-WPVQ-H0YM

Wiberg, M. (2009). Teaching statistics in integration with psychology. *Journal of Statistics Education*, *17*(1), 1-16. Retrieved from https://eric.ed.gov/?id=EJ841537

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, *25*(1), 68-81. doi:10.1006/ceps.1999.1015

Wilson, K. A., Bedwell, W. L., Lazzara, E. H., Salas, E., Burke, C. S., Estock, J. L., . . . Conkey, C. (2009). Relationships between game attributes and learning outcomes: Review and research proposals. *Simulation & Gaming*, *40*(2), 217-266. doi:10.1177/1046878108321866

Wouters, P., van Nimwegen, H., van Ostendorp, H., & van der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology, 105*(2), 249-265.

Yeager, D. S., Romero, C., Paunesku, D., Hulleman, C. S., Schneider, B., Hinojosa, C., . . . Dweck, C. S. (2016). Using design thinking to improve psychological interventions: The case of the growth mindset during the transition to high school. *Journal of Educational Psychology*, *108*(3), 374-391. doi:10.1007/s13398-014-0173-7.2

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