

Gamification of Technology-Mediated Training: Not All Competitions Are the Same

Radhika Santhanam
radhika@ou.edu
University of Oklahoma

De Liu
deliu@umn.edu
University of Minnesota

Wei-cheng (Milton) Shen
milton.shen@uah.edu
University of Alabama in
Huntsville

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Abstract

Gamification, an application of game design elements to non-gaming contexts, is proposed as a way to add engagement in technology-mediated training programs. But there is hardly any information on how to adapt game design elements to improve learning outcomes and promote learner engagement. To address the issue, we focus on a popular game design element, competition, and specifically examine the effects of different competitive structures – whether a person faces a higher-skilled, lower-skilled, or equally-skilled competitor – on learning and engagement. We study a gamified training design for databases, where trainees play a trivia-based mini-game with a competitor after each e-training module. Trainees who faced a lower-skilled competitor reported higher self-efficacy beliefs and better learning outcomes, supporting the effect of peer appraisal, a less examined aspect of social cognitive theory. But trainees who faced equally-skilled competitors reported higher levels of engagement, supporting the balance principle of flow theory. Our study findings indicate that no one competitive structure can address learning and engagement outcomes simultaneously. The choice of competitive structures depends on the priority of the outcomes in training. Our findings provide one explanation for the mixed findings on the effect of competitive gamification designs in technology mediated training.

Keywords: Gamification design, laboratory experiment, social cognitive theory, technology-mediated learning, competition, flow.

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“Tell me and I forget, teach me and I may remember, involve me and I learn.”

— Benjamin Franklin

INTRODUCTION

Training mediated via technology, often referred as technology-mediated learning (TML), e-learning, and virtual learning, is widely used in business and educational institutions (Alavi and Leidner 2001; Allen and Seaman 2011). Because TML is found to have high drop-out rates, gamification designs are proposed as a way to enhance learners’ engagement while still supporting learning goals (Greitzer et al. 2007; Gupta and Bostrom 2009; Santhanam et al. 2008; Tay 2010). Gamification is the use of game design elements in non-gaming activities to improve user engagement (Deterding et al. 2011; Kankanhalli et al. 2012; Takahashi 2010). Gamification of TML is about adding a game layer to TML, rather than developing a separate game that integrates learning and gameplay. The added game layer could make use of game artifacts (e.g., avatars and animations), game mechanics (e.g., leveling-up and competition), and even mini-games (Kapp 2013; Liu and Santhanam 2015; Takahashi 2010; Zaman et al. 2012). While gamification designs are increasingly used in learning environments such as classrooms and Massively Online Open Courses (MOOC; Burke 2012; Domínguez et al. 2013; Goh and Ping 2014), recent reports also highlight the challenges of achieving both learning and engagement goals through gamification (Pettey and Meulen 2012). Instances have been reported that game elements could create distractions for learners and even degrade engagement (Young et al. 2012). To address these challenges, recent research calls for investigations of specific gamification design elements to better design and obtain the benefits of gamification (Deterding et al. 2011; Hamari et al. 2014; Lee and Hammer 2011).

We focus on competition, a popular gamification design element. Competition refers to a contest situation in which two or more parties strive for superiority or victory (Liu et al. 2013). A gamification design with competition lets players compete with one another in a gameful way to enhance learning and engagement. The idea of using competition to enhance learning or engagement is not new. In digital game designs, competition is widely used as an engagement tool to provide challenge, interactivity, and excitement (Demetrovics et al. 2011; Liu et al. 2013; Yee 2006). In classrooms, competition is also leveraged to draw the attention of learners and motivate learning (Cheng et al. 2009; Garcia et al. 2006; Hanus and Fox 2015). But learning researchers note that competition can create anxiety and impede performance, and caution against using competition in learning settings (Kohn 1992). Given the contrasting views of competition in learning and in games, it is not automatically clear whether competition in gamified TML can simultaneously address learning and engagement goals. Moreover, most existing research contrasts competition with no competition, despite the suggestion that the effect of competition is more nuanced (Epstein and Harackiewicz 1992; Liu et al. 2013). We argue that *competitive structures*, that is, whether an individual faces a higher-skilled, lower-skilled, or equally-skilled competitor, matter for both learning and engagement goals. Gamified TML provides an excellent opportunity to implement different competitive structures and study their effects on dual goals of learning and engagement.

We focus on how learning outcomes and engagement differ across competitive structures in a gamified TML design. Competitive structures can be associated with different outcomes depending on the contexts. In economic tournaments, competitive structures can affect contestants' effort or expenditure because contestants must balance between effort expenditure and likelihood of winning (Baik 2004; Liu et al. 2007). In learning context, competitive structures can have

implications for TML outcomes such as self-efficacy and learning, because they engender different performance feedback and performance expectancies (Compeau et al. 2006; Epstein and Harackiewicz 1992; Moos and Azevedo 2009). Varying competitive structures in gamified TML can also create different challenges that may result in different levels of engagement, an understudied goal in TML literature. Hence, in this study, we compare competitive structures on three outcomes: self-efficacy, learning, and engagement.

Drawing upon social cognitive theory and flow theory, we conduct a systematic and theoretically grounded investigation of competitive structures in gamification designs. We implement different competitive structures in a gamified TML design where trainees play trivia-based mini-game after each training module to apply what they learn in a fun, competitive environment. This design follows the gamification paradigm because mini-games act as an additional game layer to TML to motivate learning, rather than as a separate game that tightly integrates learning and gameplay.¹ We found that trainees who believed they were matched with a lower-skilled competitor and won their games reported higher self-efficacy beliefs and had better learning outcomes. However, trainees who believed they were matched with an equally-skilled competitor and tied their game reported highest level of engagement. We discuss the implications of these divergent findings for developing effective gamified TML designs, and for social cognitive theory.

RELATED LITERATURE

¹ Short and self-contained mini-games are frequently used by game designers to break monotony and provide bonus experiences. For example, the classic Nintendo game *Zelda* is famously known for including mini games such as puzzles, fishing, and racing, in its game designs.

Technology-Mediated Training

Initiated by Alavi and Leidner (2001), a steady stream of Information Systems (IS) research studies evaluate TML methods for developing Information Technology (IT) skills (Gupta and Bostrom 2009; Gupta and Bostrom 2013; Santhanam et al. 2008; Sasidharan and Santhanam 2006; Wan et al. 2012). Research surveys conclude that, despite considerable progress in use of TML, problems relating to trainee disinterest persist, and alternative training designs should be investigated to create positive experiences and greater engagement for trainees (Gupta and Bostrom 2009). Interventions to support self-regulation and collaboration of trainees, among others, have been investigated but there are no studies on gamification of TML for IT skills (Gupta and Bostrom 2013; Santhanam et al. 2008).

Game-based Learning, Simulation Games, and Gamification

Before gamification, researchers and practitioners have explored game-inspired learning designs under labels such as virtual immersive learning games, digital-game-based-learning (DGBL), and serious games (de Freitas and Oliver 2006; Susi et al. 2007). These designs aim to provide learning benefits through special-purpose games so that players can learn in a game. To make the game compelling, learning and gameplay must be tightly integrated. For a few topics, such as language and history, designers were able to achieve this lofty goal, but not for others such as science or math (Young et al. 2012). Players tend to focus on gameplay that afford them entertainment value rather than learning. Moreover, these games require substantial investments and frequent updates to keep pace with players (Eck 2006; Susi et al. 2007; Young et al. 2012). Simulation games are another game-inspired design that is used for a long time in business education (Cronan et al. 2012; de Freitas and Oliver 2006; Faria and Nulsen 1998). Simulation games are special games based on simulating real-world decision scenarios with computer-based

symbolic models. Like DGBL and serious games, simulation games also require the development of a separate game that integrates learning and gameplay.

Gamification designs call for adding a game layer to non-gaming tasks rather than creating a separate full-fledged game for learning (Deterding et al. 2011; Glover 2013). The additional game layer, which is usually easy to distinguish, can add motivational affordances without taking away from time spent on learning (Kapp 2013; Zaman et al. 2012). Because gamification is an emerging topic, there are hardly any investigations on gamification of TML. Moreover, the limited number of gamification studies suffer from methodological problems, such as lack of validated psychometric measures, use of singular outcome measurements, and inability to isolate effects of specific design elements (Domínguez et al. 2013; Hamari et al. 2014).

Competition in Learning vs. Gaming

Competition is leveraged in both learning and in games, albeit for different purposes. In the former, it is to improve utilitarian outcomes such as learning, while in the latter, to improve hedonic outcomes such as engagement. Prior research shows that introducing competition in the classroom can draw the attention of students (Cheng et al. 2009; Garcia et al. 2006; Hanus and Fox 2015). However, existing evidence suggests that competition can yield both positive and negative effects (Reeve and Deci 1996; Tauer and Harackiewicz 2004). When competitive evaluations are emphasized, competition is seen as controlling, reducing learners' intrinsic motivation and creating anxiety (Reeve and Deci 1996; Tauer and Harackiewicz 2004), unless there is an emphasis on mastery (Cheng et al. 2009; Pintrich 2000).

In entertainment settings such as digital games, competition is popular and players may even compete with anonymous others. In games, competition is viewed as a source of challenge that make games intrinsically motivating (Csikszentmihalyi and Csikszentmihalyi 1975; Malone

1981). Research confirms the role of competition as a source of player motivation and engagement, although there may be individual differences (Demetrovics et al. 2011; Yee 2006).

The research on competition in gamified learning is emerging but the results are far from clear. In one study, gamified TML produced better results on practical applications of concepts than no gamification, but worse results on written assignments and participation (Domínguez et al. 2013). In classroom settings too, gamification designs using competition produce mixed results, with some showing improved student motivation and performance (Hanus and Fox 2015), while others not (Burguillo 2010). Barring a few exceptions (Epstein and Harackiewicz 1992; Liu et al. 2013), most research studies compare scenarios with and without competition, without distinguishing different competitive structures. Because of the mixed findings on competition in learning, it is important to examine the nuances of competitive structures.

HYPOTHESIS DEVELOPEMENT

We consider a gamified TML design where trainees play a mini-game after completing a learning module. Competition is part of the mini-game as a bonus activity rather than a learning assessment. Trainees experience competitive structures and may play against a higher-, equally-, or lower-skilled competitor and receive losing, tie and winning feedback, respectively. We are interested in the effects of differing competitive structures on both learning and engagement outcomes. Because learning outcomes are more utilitarian whereas engagement more hedonic and experiential, we rely on two different theories. We use social cognitive theory (Bandura 1986), the dominant theory in training research, to develop hypotheses on the effect of competitive structures on self-efficacy beliefs and learning outcomes. But social cognitive theory is rather silent on engagement and other hedonic experiences. These are better described in flow theory, which we apply to study engagement (Agarwal and Karahanna 2000; Csikszentmihalyi and

Czikszenmihalyi 1975; Malone 1981). Below we develop research hypotheses regarding self-efficacy, learning outcomes, and engagement.

Self-Efficacy

One of the most important outcomes of a training program is the learners' self-efficacy (Marcolin et al. 2000; Santhanam et al. 2013; Yi and Jang 2012). As per social cognitive theory, an individual's self-efficacy in a domain is a belief in one's capability to organize and execute the courses of action required to produce given attainments (p.3, Bandura 1997). It represents an individual's perception of capability to exert control over events of personal relevance, and complements the individual's actual capabilities (Wood and Bandura 1989). Adapting from this general notion of self-efficacy, computer self-efficacy is defined as an individual judgment of one's capability to use a computer (Compeau and Higgins 1995), and studied as a key outcome in its own right, because trainees with high self-efficacy feel confident on their ability to learn a topic, solve problems, and are more persistent (Compeau et al. 2006; Gupta et al. 2010; Johnson and Marakas 2000; Yi and Davis 2003). In TML environments, self-efficacy for using a computer to learn is most relevant because many trainees have difficulty in participating and learning in TML environments (Moos and Azevedo 2009).

As per Bandura (1997), self-efficacy beliefs could develop from several sources of information. Enactive mastery experiences derived from actual performance accomplishments are the strongest source of efficacy because they provide the most direct and authentic evidence of one's abilities. But individuals also form their self-efficacy beliefs vicariously, that is, draw inferences about one's capabilities via social comparisons, especially when the uncertainty about one's capabilities is high and there are no absolute measures of adequacy. Most IS training research has so far focused on the effect of observing an expert (such as instructors) performing a task

(Compeau et al. 2006; Johnson and Marakas 2000; Yi and Davis 2003). But experts may not be the best performance benchmarks for trainees because they have far superior skills. In TML contexts where instructors are often absent, the performance of fellow trainees can be an important source of self-efficacy information, because vicarious experiences are most salient when comparison targets are similar to individuals (Bandura 1986; Compeau et al. 2006).

A gamified TML design with competition provides an opportunity for trainees to compare themselves with peer trainees in a gameful context. By comparing performances with peers in a gameful competition, they can infer their own capabilities to learn in TML environments. Bandura (1997) suggested that social comparisons can be used to judge one's self-efficacy: low relative performance signifies low efficacy whereas high relative performance indicates high efficacy. Thus, trainees, who are matched with a lower-skilled competitor, find themselves outperforming their peers and get positive relative performance feedback. Thus, they are most likely to improve their self-efficacy beliefs on learning through TML, when compared to those in other competitive structures. Hence:

Hypothesis 1: In gamified TML, trainees matched with a lower-skilled competitor (L) will exhibit higher levels of *self-efficacy* for learning through TML than those matched with an equally- or higher-skilled competitor (EH).

Learning Outcomes

While self-efficacy beliefs are important training outcomes in their own right, training designs must also produce tangible learning outcomes. Learning outcomes consist of both cognitive- and skill-based outcomes (Yi and Davis 2003; Yi and Jang 2012). Cognitive outcomes, referred also as declarative knowledge, assess the trainee's conceptual understanding of the domain, while skill-

based outcomes, referred also as procedural knowledge, assess the trainee's ability to apply this knowledge to complete a task (Santhanam et al. 2008).

Learning enhancement may occur during a game competition (as is the goal of many GBL designs) or after. This study focuses on the latter. A game competition, such as in a mini-game after a learning module, can affect learning outcomes in the next module in two different ways. Positive performance feedback from winning can provide comparative information that enhances trainees' self-efficacy beliefs. Trainees who become more confident in their abilities tend to approach learning tasks with more interest and pay greater attention to the content (Johnson and Marakas 2000; Webster and Hackley 1997; Yi and Davis 2003). Meanwhile, competition allows trainees to form expectancies of success or failure by learning how good their competitors are. Unlike self-efficacy beliefs which are internally focused and affected by performance outcomes, performance expectancies are externally focused (e.g., affected by competitors' skills) and formed at the onset of competition, before the final outcomes are known. As shown by Epstein and Harackiewicz (1992), performance expectancies can influence how individuals approach and experience a task, independent of their self-efficacy beliefs. Individuals who face an inferior competitor will develop an interest in the task and approach it with greater enthusiasm (Epstein and Harackiewicz 1992; Reeve and Deci 1996; Tauer and Harackiewicz 1999). In our context, trainees who compete with a lower-skilled competitor in the first mini-game will develop an expectancy to win again in the next mini-game, which makes trainees approach the new learning module with enthusiasm and thus achieve better learning outcomes. Hence:

Hypothesis 2: In gamified TML, trainees matched with a lower-skilled competitor (L) will exhibit higher levels of *learning outcomes* in the next training module than those matched with an equally- or higher-skilled competitor (EH).

Engagement

A main goal of gamification is to make an activity engaging (Domínguez et al. 2013). Although the idea of creating engagement by gamification is emerging in the training literature, training researchers generally recognize that trainees must leave the training session with not only knowledge acquisition but also positive experiences. Thus far, the training literature has used a variety of measures such as flow and enjoyment but there are no standards to assess these hedonic outcomes (Santhanam et al. 2013; Yi and Jang 2012).

In digital games, the experiences of engulfing enjoyment and total immersion are often described using the concept of *flow*, because such deep engagement is often accompanied by a loss of sense of time, and is pursued for its own sake (Csikszentmihalyi and Csikszentmihalyi 1975; Keller and Bless 2008; Malone 1981). In Information Systems literature, Agarwal and Karahanna (2000), based on flow theory, further propose *cognitive absorption* to describe a sense of being totally engaged and immersed in one's interactions with an information system. Hence, we use cognitive absorption as a lens to study engagement in gamified TML.

Cognitive absorption is exhibited through several dimensions, including temporal dissociation (the inability to register the passage of time while engaged in interaction), focused immersion (the experience of total engagement where other attentional demands are ignored), heightened enjoyment (which captures the pleasurable aspects of the interaction), control (the perception of being in control over the interaction), and curiosity (heightened arousal of cognitive and sensory curiosity). Researchers suggest that appropriate dimensions of cognitive absorption should be used based on the types of hedonic experiences expected in a given context (Lowry et al. 2013; Rutkowski et al. 2007). We choose three dimensions of cognitive absorption, namely *enjoyment*, *focused immersion*, and *temporal disassociation*, as measurements for engagement in gamified

TML designs. Although control and curiosity also frequently accompany engaging experiences, they are considered sources of such experiences (Malone 1981), rather than directly describing engaging experiences.

To establish the relationship between competitive structures and dimensions of cognitive absorption, we rely on the balance principle from the flow literature. According to this literature, one of the precursors to the state of total absorption is the balance between skill and challenge (Csikszentmihalyi 1988; Engeser and Rheinberg 2008). Imbalances between skill and challenge can lead to suboptimal experiences such as boredom and frustration. Extending the balance principle from an individualist setting to a competitive setting, we propose that a state of cognitive absorption would also result from a balance between competitors' skills. When a trainee is playing against a competitor of higher skills, the trainee may feel unable to win, experience anxiety, and lose attention. When a trainee competes against a competitor of lower skills, the trainee does not feel challenged and a sense of boredom and apathy may ensue. Only when a trainee plays against an equally-skilled competitor, the suspense of not knowing the final outcome and the challenge of an equally-skilled competitor will keep the trainee immersed. The experiences of cognitive absorption, once initiated by the game competition, can spill over to other parts of the training session, coloring trainees' perception of the entire training experiences. Based on the above, we state our third hypothesis as:

Hypothesis 3: In gamified TML, trainees matched with an equal-skilled competitor (E) will exhibit higher levels of *enjoyment*, *focused immersion*, and *temporal disassociation* than those matched with a lower or higher-skilled competitor (LH).

RESEARCH METHOD

We develop a TML design where users learn through a series of video-based training modules without instructor intervention. We gamify the TML design, so that at the end of each TML

module, a trainee will be quizzed on the module content but will also play a trivia game against a fellow competitor, based on questions exclusively drawn from the preceding TML module. To test our research hypotheses, we designed a two-phase laboratory experiment, each of which consists of a TML module, a written test for learning outcomes, and a mini-game competition. The goal of the mini games is not to provide a formal learning assessment, but to provide engaging experiences, performance feedback, and performance expectancies as trainees continue to learn through the TML program. To minimize fatigue, we limited the experiment to two TML modules each followed by a mini-game.

TML Modules and the Millionaire Game

The TML content used in the experiment focuses on introductory database management concepts and skills. We recorded two Camtasia video lectures with voice narration for the two TML modules.² TML Module 1 covered basic database concepts, such as the value of databases, the concept of relational databases, the main activities in the database design. Module 2 covered topics such as database management systems, elements of Microsoft Access, and basic queries with Microsoft Access. Trainees could navigate different sub-topics in each module using a menu, and pause, forward, and backward the video lectures. To avoid confounds, we did not introduce any game feature within the TML modules.

The mini-game used in the experiment was adapted from a Java-based mobile game, “Who Wants to be a Millionaire?” (Hereafter, referred as the *Millionaire game*). The game mimics the TV game of the same title with features such as (virtual) prizes, (simulated) applause, a 50/50 lifeline, a walk-away option, and background music matched to the intensity of game levels (See

² Please refer to the Online Appendix for screenshots of the TML module (A1), the mini-game (A2), the background survey (A3), measurements during the experiment (A4), sample questions for learning outcomes (A5), the grading scheme for problem solving questions (A6), and experimental scripts (A7).

A2 for a screen shot of the game).³ We adapted the Millionaire game by adding a competitive element whereby the trainee believed that they were in competitive play with another trainee to get maximum scores. To minimize confounds, we simulated the fellow competitor and used manipulation checks to ensure that trainees felt that they were competing with a real person.

Trainees

We used students in a large business course at a large southeastern university as participants of our training study. As an institutional practice, students in this course are required to obtain research experience credits by participating in a research project or writing an essay. We recruited 182 business students, among which 31% majored in finance, 15% in management, 11% in information systems, 34% in non-business majors, and 14% were undecided. The average age of the trainees was 21, ranging from 19 to 34.

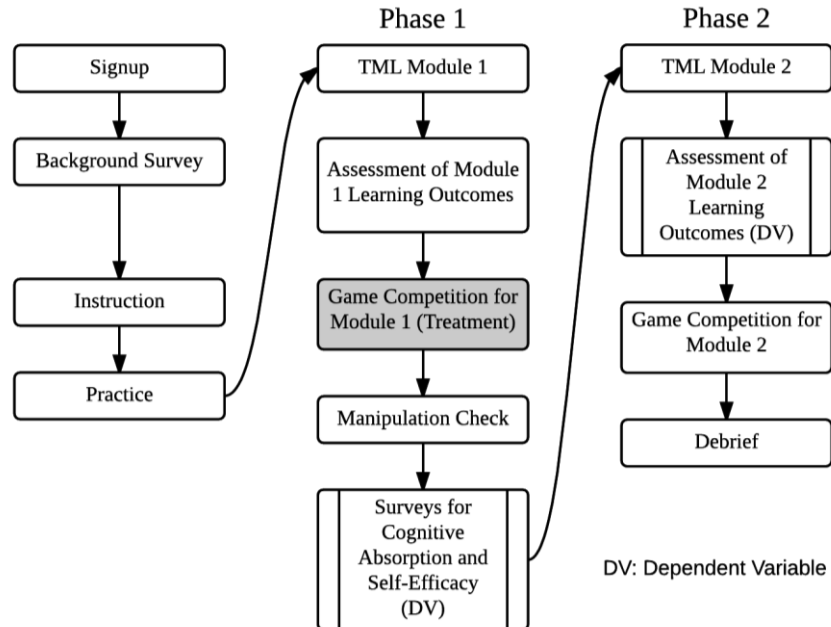
Experimental Procedures

We conducted two pilot studies with 50 and 24 trainees, respectively, and refined our experimental procedures, adjusted the length of the TML modules, improved instructions on the game, and revised questions for learning outcomes. In the final design, each TML module lasted 12-15 minutes and the entire experiment took about 90 minutes to complete. The experiment was conducted at a research lab with 16 small cubicles, each of which has a computer, a working space, and a headset. Trainees were blocked in their cubicle and could not look at or talk to another

³ “Who Wants to Be a Millionaire?” is a television game show, where large cash prizes are offered for correctly answering a series of multiple-choice questions of increasing difficulty. Each question has four possible answers and the player must choose one within a set time limit. Upon answering a question correctly, the contestant wins a certain amount of money and the opportunity to challenge the next question with greater difficulty and money prize. If a player gets a question wrong, the prize drops to the previous guaranteed prize. After viewing a question, the player can “walk away”, i.e., leave the game with the money already won rather than attempting an answer. Players are given a series of lifelines to aid them with difficult questions, including 50:50, where the computer eliminates two of the incorrect answers, “asking the audience” where the audience is polled and answer statistics are shown to the player, and “phone a friend”, where the player can call a designated friend to get his/her opinion. We did not implement the “ask the audience” or “phone a friend” feature of the TV version as it was not possible for our setting.

trainee. A proctor blind to the treatments was asked to make notes on any irrelevant behavior, such as falling asleep, web-surfing, or studying for an exam.

Figure 1 Experimental Procedures



As shown in Figure 1, trainees first registered online for one of the several experiment slots. At this time we collected information on their gender, GPA, academic status, computer experience, prior knowledge on spreadsheets and databases, and individual difference variables, such as goal orientation and trait measure of computer learning self-efficacy (A3).⁴ When they arrived, we gave instructions on how to use the TML modules and the game, and informed them that they would compete with a fellow trainee after each TML module (A7). Trainees played a practice Millionaire game without a competitor for 10 minutes using trivia questions such as “Whose portrait is on the U.S. dime?” After the practice session, they were provided TML Module 1, followed by a learning outcome assessment using a paper and pencil test, which would be used as a baseline control for

⁴ As in prior TML research (Santhanam et al. 2008), we used both trait measure and state measure of computer learning self-efficacy because the former captures sustained and consistent characteristic of an individual under different situations, which is used as a control for individual differences, and the latter is situation-specific, which serves as a response to our experimental treatments.

learning outcomes (A5).⁵ Trainees then proceeded to the first game competition, in which we randomly assigned each trainee to one of the three treatment conditions (higher-, equal-, or lower-skilled competitor). We simulated the fellow competitor and told trainees that they were randomly paired with a fellow trainee (referred to as “your competitor”) who was playing simultaneously in a different room. A trainee could not see her competitor’s screen but received periodic on-screen performance feedback (e.g., “Your competitor is scoring lower than you.”) and a final outcome report (A7-F). To increase realism, we simulated the completion time of the competitor, and asked trainees who finished a TML module quickly to wait for their competitor (A7-E). After the game competition was over, trainees answered a manipulation check question about their relative performance in the game, including an option of “there was no competitor” (A7-G). Trainees then proceeded to answer questions, on our dependent variables, regarding enjoyment, focused immersion, temporal disassociation, and state measures of computer learning self-efficacy. Next, in Phase 2 of the experiment, they went through TML Module 2, and completed a paper-and-pencil assessment for learning outcomes, as another dependent variable. After this, trainees played the game competition for Module 2. Trainees were debriefed and dismissed.

Measurements

We used validated scales to measure reflective constructs on individual differences, including learning orientation, performance orientation - approach, performance orientation - avoidance (Zweig and Webster 2004), and state and trait measures of computer learning self-efficacy (Santhanam et al. 2008; Zweig and Webster 2004) (A4). For enjoyment, focused immersion, and temporal disassociation, we adapted scales from (Agarwal and Karahanna 2000). We measured a

⁵ We measured learning outcomes after TML Module 1 mainly for the purpose of controlling for individual differences, in addition to our background questions on spreadsheet and database knowledge. The learning outcomes as a dependent variable were measured after TML Module 2.

trainee's knowledge level in spreadsheets and databases using self-reported questions on the scale of low, medium, and high (A3).

Based on prior studies on IS training (Santhanam et al. 2008; Yi and Davis 2003), we developed multiple-choice, short-answer, and problem-solving questions to measure cognitive and skill-based learning outcomes (A5). The multiple-choice and short-answer questions had distinct identifiable objective answers. For problem-solving questions, which entailed subjective grading, we provided two graders a detailed grading scheme (see A6 for an example) that was developed based on prior studies (Antony and Santhanam 2007) and trained them with test cases. The two graders were well versed in database and blind to treatment conditions. We calculated Cronbach's alpha, which was greater than .90, suggesting a high inter-grader agreement. Finally, two graders met to resolve any discrepancy in their grades and a final consensus on grades was used for data analysis.

Covariates

As shown in Figure 1, we collected information on several control variables in our analysis, such as gender, GPA, academic status, computer experience, self-reported prior knowledge of spreadsheets and databases. We controlled for individual difference variables of goal orientation, and the trait variable of computer learning self-efficacy. We obtained learning outcome scores of trainees after TML Module 1, using a paper and pencil test, and used them as a control of trainee's prior knowledge. Because the absolute game performance (as measured by the number of questions answered correctly in the game) may also affect self-efficacy, we also controlled for trainees' absolute game performance.

RESULTS

Table 1 Descriptive Statistics

	Range	All n=144	L n=51	E n=45	H n=48	ANOVA		KW
						F	p	p
Percentage of Males	-	61.8%	60.8%	57.8%	66.7%	.400	.671	.668
Age	19-34	20.99 (1.93)	21.06 (2.27)	20.75 (1.45)	21.15 (1.95)	.525	.593	.646
Academic Status	-	20	5	8	7	-	.740^	
Freshman		90	35	27	28			
Sophomore		34	11	10	13			
Junior								
GPA	0-4	2.96 (.48)	3.00 (.51)	2.92 (.45)	2.96 (.49)	.363	.696	.588
Knowledge in Databases and Spreadsheets	0-4	1.39 (.97)	1.33 (.77)	1.33 (1.04)	1.52 (1.09)	.595	.553	.689
Computer Usage (hours/day)	1-11	3.43 (1.91)	3.41 (1.87)	3.42 (1.71)	3.46 (2.14)	.008	.992	.789
Gaming Experience (hours/day)	0-4	.85 (.85)	.78 (.66)	.82 (.86)	.94 (1.00)	.463	.630	.946
Learning Orientation	1-7	5.84 (.76)	5.90 (.81)	5.72 (.69)	5.90 (.76)	.869	.422	.285
Performance Orientation -Approach	1-7	5.66 (.91)	5.64 (.96)	5.64 (.76)	5.71 (1.01)	.102	.903	.870
Performance Orientation - Avoidance	1-7	3.77 (1.11)	4.00 (1.14)	3.77 (1.14)	3.52 (1.02)	2.346	.099*	.141
Computer Learning Self-Efficacy (Trait)	1-7	5.48 (.99)	5.49 (.96)	5.45 (1.03)	5.50 (.99)	.031	.970	.999
Absolute Game Performance	0-12	6.25 (2.22)	6.24 (2.53)	6.48 (1.61)	6.04 (2.38)	.446	.641	.726
* denotes $p < 0.1$; L, E, and H denote lower-, equally-, and higher-skilled competitor respectively. ^ denotes Pearson's Chi-Square test. KW shows the results of the Kruskal-Wallis one-way ANOVA. Standard deviations are shown in parenthesis.								

Trainees

Among the 182 subjects, eight trainees had incomplete data on key variables, and had to be dropped. Four other trainees were excluded due to technical problems (e.g., frozen game screen or game performance not logged). Prior to data analysis, we read the proctor's notes and removed twelve trainees who failed to follow instructions (e.g., sleeping, texting, bypassing TML modules,

and studying for an exam).⁶ We then excluded fourteen trainees who failed to correctly answer the manipulation check question which queried trainees on whether they had won their competition. In the end, data for 144 trainees remained usable for our analyses.

Table 1 shows descriptive statistics of the trainees by treatment conditions. As shown in the table, no significant difference was detected across treatments in gender, age, GPA, knowledge in databases and spreadsheets, academic status, computer usage, or gaming experience, suggesting a successful random assignment of trainees. The Kruskal–Wallis one-way ANOVA showed similar results. However, ANOVA showed a marginally significant difference in performance orientation - avoidance ($p=.099$); thus, we included it as a covariate along with other individual characteristics to statistically mitigate their potential confounding effects.

Table 2 Correlation Coefficients, Reliability, and Validity

Constructs	Mean (S.D.)	# of Items	CA	CR	AVE	Correlation Matrix						
						1	2	3	4	5	6	7
1: Computer Learning Self-efficacy	5.48 (.99)	6	.90	.93	.68	.82						
2: Enjoyment	4.40 (1.40)	4	.94	.96	.85	.09	.92					
3: Focused Immersion	4.56 (1.06)	4	.78	.84	.58	.15	.70	.76				
4: Temporal Dissociation	3.92 (1.45)	3	.93	.96	.88	-.02	.69	.56	.94			
5: Learning Orientation	5.84 (0.76)	7	.90	.92	.64	.41	.07	.15	.07	.80		
6: Performance Orientation Approach	5.66 (.91)	5	.81	.85	.55	.16	.18	.18	.16	.27	.74	
7: Performance Orientation Avoidance	3.77 (1.11)	6	.84	.88	.56	-.14	-.04	-.06	.12	-.26	.05	.75
Note: S. D. denotes Standard Deviation; CA denotes Cronbach's Alpha; CR denotes Composite Reliability; AVE denotes Average Variance Extracted; Diagonal elements are the square roots of AVE.												

⁶ These students appeared to come to our study merely for obtaining research experience credits, but as per IRB protocols, we could not ask them to leave. Instead, we relied on the proctor's notes to remove them to avoid data contamination. We conducted robustness checks by including these records and our results still hold, but to maintain data and experimental integrity, their records were excluded.

Tests of Validity and Reliability: We used SmartPLS 2.0 M3 to test measurement properties of our constructs (Ringle et al. 2005). We dropped several items due to low factor loadings on their respective reflective constructs. Items used in the study and their factor loadings are shown in Online Appendix (A3 and A4). Table 2 shows the descriptive statistics, number of items, Cronbach's alpha, composite reliability, average variance extracted (AVE) for these reflective constructs and their correlations. The tests of convergent and discriminant validity were satisfied, with the measurement items loading together and the square root of the AVE greater than the correlation between the constructs. Cronbach's alpha scores were greater than 0.7, suggesting adequate reliability of the scales.

Test of Hypotheses – Self-Efficacy and Learning Outcomes

Table 3 ANCOVA Results on Self-Efficacy and Learning Outcomes

	(1)	(2)	(3)	(4)
	H1: Computer Learning Self-Efficacy L > EH	H2: Learning Outcomes L > EH		
Dependent Variable	Computer Learning Self-Efficacy (State)	Multiple Choice	Short Answers	Problem Solving
Treatment: F-value (p-value)	2.85 (.047**)	.54 (.232)	.88 (.175)	3.25 (.037**)
Covariates: F-value (p-value)				
Gender	1.34 (.249)	.11 (.737)	8.32 (.005***)	.35 (.557)
Knowledge in Databases and Spreadsheets	.03 (.871)	2.77 (.098*)	2.14 (.146)	6.53 (.012**)
Learning Orientation	.36 (.548)	.59 (.445)	.22 (.641)	.10 (.757)
Performance Orientation – Approach	1.32 (.253)	.93 (.337)	.46 (.501)	.13 (.716)
Performance Orientation – Avoidance	4.84 (.030**)	.35 (.555)	1.48 (.225)	.31 (.577)
Computer Learning Self-Efficacy (Trait)	25.58 (.000***)	6.40 (.013**)	.47 (.494)	.18 (.673)
Absolute Game Performance	5.11 (.025**)	2.56 (.112)	4.59 (.034**)	13.59 (.000***)
TML1 Score – Multiple Choice		3.91 (.050*)		
TML1 Score – Short Answer			6.75 (.010**)	
TML1 Score – Problem Solving				5.24 (.024**)
Model Adjusted R²	.221	.097	.127	.185

Marginal Estimated Means (Standard Error)				
L (n=51)	5.49 (.13)	3.84 (.14)	11.23 (.89)	30.34 (1.40)
EH (n=93)	5.22 (.09)	3.71 (.10)	10.19 (.65)	27.17 (1.03)
E (n=45)	5.23 (.13)	3.66 (.14)	10.25 (.95)	27.53 (1.52)
H (n=48)	5.21 (.13)	3.77 (.14)	10.13 (.92)	26.83 (1.46)
Possible Range	1-7	0-5	0-20	0-40
***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.10$; L denotes lower-skilled competitor. EH denotes higher- or equally-skilled competitor. Marginal estimated means and associated SEs show the central tendency and dispersion of the dependent variables <i>after controlling for the impact of covariates</i> .				

We conducted Analysis of Covariance (ANCOVA) to examine the treatment effect of competitive structure, after controlling for individual differences and prior knowledge. Table 3 Column 1 shows the effects of gamification on self-efficacy (H1). The trait measure of computer learning self-efficacy ($p < .001$) and performance orientation - avoidance ($p = .030$) were significant covariates, as was game performance ($p = .025$). After controlling for these effects, we found that trainees matched with a lower-skilled competitor (i.e., receiving feedback of winning) reported higher levels of self-efficacy beliefs than those matched with an equally- or higher-skilled competitor ($p = .047$). We tested the robustness of this finding using bootstrapping with 1,000 samples and obtained similar results. These provided empirical support for **Hypothesis 1** that “trainees matched with a lower-skilled competitor will exhibit higher levels of *self-efficacy* for learning through TML than those matched with an equally- or higher-skilled competitor.”

Columns 2-4 of Table 3 show the effect of gamification on learning outcomes, including scores in multiple-choice, short-answer, and problem-solving questions (H2). As expected, TML Module 1 scores and prior knowledge in databases and spreadsheets were significant covariates. Marginal estimated means, which indicate the central tendency of the dependent variables after controlling for the impact of covariates, were higher for the treatment group. However, only problem solving scores showed statistical significance ($p = .037$). Robustness tests using bootstrapping with 1,000 samples yielded similar results. We additionally analyzed the treatment effect on synthesized learning outcomes, obtained through Principal Component Analysis on three scores, and obtained

a marginally significant effect ($p=.067$). In sum, the results provide partial support for our **Hypothesis 2** that “trainees matched with lower-skilled competitors will exhibit higher levels of *learning outcomes* in the next training module than those matched with equally- or higher-skilled competitor.”

Table 4 shows the treatment effect of competitive structures on enjoyment, focused immersion, and temporal dissociation (H3). After controlling for covariates, we found that trainees competing with an equally-skilled competitor reported marginally significant higher enjoyment ($p=.090$) and temporal dissociation ($p=.098$), but not focused immersion. Bootstrapping with 1,000 samples yielded similar results. We additionally analyzed the treatment effect on a synthesized engagement variable, obtained via Principal Component Analysis on enjoyment, focused immersion, and temporal disassociations, and found a significant effect ($p=.073$). Overall, we found partial support for **Hypothesis 3** that “trainees matched with an equally-skilled competitor will exhibit higher levels of *enjoyment*, *focused immersion*, and *temporal disassociation* than those matched with a lower or higher-skilled competitor.”

Table 4 ANCOVA Results on Enjoyment, Focused Immersion, and Temporal Dissociation

	(1)	(2)	(3)
	H3: Engagement – E > LH		
Dependent Variable	Enjoyment	Focused Immersion	Temporal Dissociation
Treatment: F-value (p-value)	1.82 (.090*)	1.09 (.149)	1.69 (.098*)
Covariates: F-value (p-value)			
Gender	2.72 (.101)	3.16 (.078*)	1.53 (.219)
Knowledge in Databases and Spreadsheets	3.51 (.063*)	2.92 (.090*)	2.38 (.125)
Learning Orientation	.08 (.773)	0.19 (.660)	.74 (.392)
Performance Orientation - Approach	2.62 (.108)	.42 (.520)	1.25 (.265)
Performance Orientation - Avoidance	.41 (.525)	.27 (.604)	1.41 (.237)
Computer Learning Self-Efficacy (Trait)	1.64 (.202)	2.48 (.117)	.01 (.930)
Absolute Game Performance	1.63 (.224)	6.46 (.012**)	.52 (.472)
Model Adjusted R²	.051	.073	.030
Marginal Estimated Means (Standard Error)			
E (n=45)	4.64 (.21)	4.70 (.15)	4.15 (.21)
LH (n=99)	4.30 (.14)	4.50 (.10)	3.81 (.14)

L (n=51)	4.60 (.19)	4.66 (.14)	4.03 (.20)
H (n=48)	3.99 (.20)	4.34 (.15)	3.58 (.21)
Possible Range	1-7	1-7	1-7
***: p <0.01, **: p <0.05, *: p <0.10; E denotes equally-skilled competitor. LH denotes lower- or higher-skilled competitor. Marginal estimated means and associated SEs show the central tendency and dispersion of the dependent variables <i>after controlling for the impact of covariates</i> .			

DISCUSSION

Gamification is suggested as a promising strategy to increase engagement of learners in TML, but nuanced analysis is required to understand how to address engagement and learning goals with game designs (Hamari et al. 2014; Liu and Santhanam 2015). Using a gamified TML design with different competitive structures, we show that addressing both goals simultaneously could be inherently challenging. Consistent with social cognitive theory, we find that trainees' self-efficacy beliefs and learning outcomes were higher when they believed they competed against a lower-skilled competitor, won their games and received winning performance feedback. But, as suggested by the flow theory, engagement in TML was the highest in a more balanced competitive structure. These findings echo the sentiment of researchers that it is important to explicate the effects of each gamification design element and evaluate them on both utilitarian and hedonic outcomes.

Theoretical and Practical Implications

Premised on the arguments that competitive structures can alter how trainees approach training tasks, we argued and found support for the idea that the effects of competition on learning outcomes and engagement differ across competitive structures. Because different competitive structures can have different effects on player learning, they can contribute to the mixed effects of competition in gamified training studies. In light of the mixed effects of competition in gamification designs (Burguillo 2010; Hamari et al. 2014; Hanus and Fox 2015), our study

suggests that future research should report the competitive structures and isolate effects of different competitive structures to allow comparisons across studies.

To address the utilitarian and hedonic goals of gamification, we used two different theories, namely social cognitive theory and flow theory, respectively. We found that the two disjoint theory traditions intersect and provide divergent predictions regarding competitive structures. Specifically, social cognitive theory, which addresses utilitarian outcomes such as learning and achievements, favors competing with a less-able competitor. However, flow theory, which address hedonic outcomes such as engagement, call for a tighter race. Our initial findings reveal the complexity of using competition as a gamification tool, and post intriguing challenges on how to integrate theories for learning and engagement.

By applying social cognitive theory and flow theory in novel contexts, we contribute to each theory tradition. Social cognitive theory predicts that self-efficacy beliefs can be molded by vicarious experiences of observing the performance of others, which has led to extensive research on behavioral modeling and vicarious learning from proficient models (Compeau et al. 2006; Compeau and Higgins 1995; Yi and Davis 2003). We tested a less-studied source, namely, social comparisons among peers through gamified competition. Our findings support the idea that online social settings, such competitive vicarious experiences can be a valuable source of self-efficacy beliefs. We also contribute to the flow literature by extending the balance principle to two-person competitive situations by showing the engagement is highest when there is a balance of skills among competitors. Our results hold promise for multi-person extensions where multiple individuals compete individually or in groups.

From a practical perspective our findings suggest that not all competition is the same and there may not be a one-size-fits-all competition design. Hence, organizations could optimize gamified

training designs based on the priority of their training goals and characteristics of the individuals. For example, in cases where improving trainees' self-efficacy is important, matching trainees with a lower-skilled competitor is the most preferred competitive situation. In cases where providing fun and engaging experiences is a priority, trainees could be matched with equally-skilled competitors so that they become more challenged and stay engaged. TML platforms could personalize competition. For example, if the TML platform detects a bored trainee, it may have her compete against a fellow trainee of similar skill. Our design also adds to the emerging research of mitigating ill-effects of competition in learning environments (Cheng et al. 2009; Hanus and Fox 2015): we suggest another approach, that is, to provide competence evaluations as game performance feedback.

Limitations and Future Research

As a study of a new gamified TML design, our research has a few limitations that call for further investigations. Our gamified TML approach should be tested in domains other than database training. Further research is needed using non-student trainees, though students are future employees and an appropriate audience for gamification. We did not find significant effects on multiple choice and short answer questions, perhaps because we had relatively few such questions. We did find support on problem-solving questions, however, which are generally considered the most critical test of learning because they evaluate the depth of understanding (Santhanam and Sein 1994; Yi and Davis 2003). Our effect sizes on learning and engagement were small but stable in additional robustness tests. The small effect sizes may partly reflect our conservative experimental design, which used a simulated competitor to maximize control. Field tests will be worthwhile because they provide more realistic effect sizes.

As one of the first studies on competitive structures in gamification, it offers a host of opportunities for extensions. Some natural extensions of our study include determining the optimal sequence and transitions of competitive structures, the optimal combination of training and mini-games, and moderating effects of social relations between competitors. Theoretical lens such as social comparison theory could be used to study cases where individuals can choose whether and with whom they want to compete (Dijkstra et al. 2008; Festinger 1954; Garcia et al. 2006). Another extension is to enrich existing game-theoretical models of competition (Kalra and Shi 2001; Liu et al. 2007) by incorporating self-efficacy and engagement.

From a broader IS research perspective, there is now a greater thrust toward building systems that offer both, hedonic and utilitarian benefits (Lowry et al. 2013; Wu and Lu 2013). Our study directs attention to gamification as a useful design paradigm that addresses both types of benefits. It also highlights that many nuances in gamification design must be addressed with relevant theoretical frameworks, suggesting many opportunities for IS researchers.

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Online Appendix

A1 - Screenshot of the TML Modules

The screenshot shows a video player interface. On the left is a table of contents for the TML Modules. The main area displays a video slide titled 'Introduction - Database'.

Module Number	Module Title
1.	Learning Module 1
2.	Learning Objectives
3.	Introduction - DB
4.	Why Learn DB?
5.	Traditional File Processing Approach
6.	The Database Approach
7.	Relational Database - Introduction
8.	Relational Database - An Example
9.	Relational Database - Primary Key
10.	Relational Database - Foreign Key
11.	ERD - Introduction
12.	ERD - Notations
13.	ERD - Relationship Cardinality
14.	ERD - Identify Entities
15.	ERD - Identify Primary Keys
16.	ERD - Identify Relationships
17.	End

Introduction - Database

- Small and large companies use databases to record business transactions, employee information, and customer relationships.
- As of 10/14/2008, **1 petabyte = 1 million gigabytes**
 - Yahoo!: > 1 petabyte
 - Facebook: > 1 petabyte
 - eBay: > 5 petabytes
 - Wal-Mart: > 2.5 petabytes

A2 - Screenshot of the Millionaire Game

The screenshot shows the Millionaire Game interface. It has a blue title bar and a menu bar with 'File'. The main area is divided into three sections: 'Message Screen', 'Score Screen', and 'Game Screen'.

Score Screen:

Question Number	Prize Amount
12	\$ 1 MILLION
11	\$ 500,000
10	\$ 250,000
9	\$ 125,000
8	\$ 64,000
7	\$ 16,000
6	\$ 4,000
5	\$ 2,000
4	\$ 1,000
3	\$ 500
2	\$ 200
1	\$ 100

Game Screen:

Trying for: \$ 1,000

Time: :59

Score: 50/50

Q: A database that stores all data in two-dimensional tables is a _____ database

Answers:

- A: hierarchical
- B: relational
- C: network
- D: object-oriented

A3 – Background Survey

A. Selected Background Questions

Please rate your knowledge of the following software

- Spreadsheet (e.g., Microsoft Excel): Low/ Medium/ High
- Database software (e.g., Microsoft Access): Low/ Medium/ High

B. Measurements of Individual Differences and Their Factor Loadings

Computer Learning Self-Efficacy (Trait; Reflective) (Santhanam et al. 2008; Zweig and Webster 2004)

- I feel confident using a computer to learn about and apply new concepts (.81)
- Using a computer is an efficient way for me to learn new things (.76)
- I could apply new concepts that I learned from a computerized training program. (.85)
- It would be easy for me to become skillful at tasks learned from this computerized training program (.77)
- I would be comfortable using a computer-based training program. (.90)
- I could successfully use a computer-based training program. (.84)

Learning Orientation (Reflective) (Zweig and Webster 2004)

- The opportunity to do challenging work is important to me. (.83)
- I prefer to work on tasks that force me to learn new things. (.78)
- If I do NOT succeed on a difficult task, I plan to try harder the next time. (.69)
- In learning situations, I tend to set fairly challenging goals for myself. (.80)
- I am always challenging myself to learn new concepts. (.85)
- The opportunity to extend my range of abilities is important to me. (.83)
- The opportunity to learn new things is important to me. (.79)

Performance Orientation – Approach (Reflective) (Zweig and Webster 2004)

- I value what others think of my performance. (.74)
- It's important for me to impress others by doing a good job. (.67)
- I do NOT care what others think of my performance. (Reversed; .88)
- I am NOT interested in impressing others with my performance. (Reversed; .85)
- The opinions others have about how well I can do certain things are important to me. (.53)

Performance Orientation – Avoidance (Reflective) (Zweig and Webster 2004)

- Typically, I like to be sure that I can successfully perform a task before I attempt it. (.51)
- I don't enjoy taking on tasks if I am unsure whether I will complete them successfully. (.76)
- I avoid circumstances where my performance will be compared to others. (.70)
- Most of time, I stay away from tasks that I know I won't be able to complete. (.88)

- I worry that I won't always be able to meet the standards set by others. (.66)
- I avoid tasks that I may not be able to complete. (.91)

A4 – Measurements after the Game Competition for Module 1

Please rate your experience so far in this game-based learning session. There are no right or wrong answers to the questions below. Honest responses will give us the most valuable information:

Enjoyment (Reflective) (Agarwal and Karahanna 2000)

- I am having fun (.95)
- Activities in this session provide me with a lot of enjoyment (.94)
- Activities in this session bore me (.82)
- I enjoy activities in this session (.96)

Focused Immersion (Reflective) (Agarwal and Karahanna 2000)

- I am able to block out most other distractions. (.65)
- I am absorbed in what I am doing. (.91)
- I am immersed in the task I am performing. (.90)
- My attention does not get diverted very easily. (.52)

Temporal Dissociation (Reflective) (Agarwal and Karahanna 2000)

- Time appears to go by very quickly (.96)
- Sometimes I lose track of time in this session (.91)
- Time flies when I am in this session (.95)

Computer Learning Self-Efficacy (State; Reflective) (Santhanam et al. 2008; Zweig and Webster 2004)

- I feel confident using a computer to learn about and apply new concepts. (.88)
- I feel using a computer is an efficient way for me to learn new things. (.81)
- I could apply new concepts that I learned from this computerized online training program. (.84)
- I do not feel that I could learn new skills from this computerized training program. (.68)
- It would be easy for me to become skillful at tasks learned from this computerized training program. (.87)
- I am comfortable using a computer-based training program. (.92)
- I feel that I could successfully use a computer-based training program as in this session. (.85)

A5 - Sample Questions for Learning Outcomes

Selected Multiple Choice Questions

A field identified in a table as holding the unique identifier of the table's records is called the ____.

A. primary field; B. foreign key; C. primary key; D. unique ID; E. I Don't Know

In a relational database, a row represents a(n) ____.

A. entity; B. attribute; C. field; D. relationship; E. I don't know

Selected Short Answer Questions

Name two problems associated with the file processing approach to data management.

Name three popular database management systems.

Selected Problem Solving Question

A toy designer keeps tracks of customer orders in an orders table in an Access database. The sample data in this table is illustrated below [omitted]. The first row contains the field names. Please use the blank query design grids for the following three tasks

- 1. Query the Orders table and show orderNumber and status.*
- 2. Select a subset of orders where the customerNumber must be 1221 and status must be "Shipped".*
- 3. Select a subset of orders where the orderDate is no later than September 08, 2009.*

A6 - Grading Scheme for Problem-Solving Questions

Grading Scale for TML Module 1

- **Entity (20 points in total):** (for each of the three entities) Missing =0; Correct= 6; Correct primary key but incomplete or extra non-key attributes =5; Missing or wrong primary key but correct non-key attributes =4; Missing or wrong primary key, incomplete or extra non-key attributes, but at least one correct non-attribute =3; (overall) Number of correct entities >0 and no extra entity =2.
- **Relationships (20 points in total):** (for each of the three relationships) Missing =0; Correct =6; Correct cardinality but wrong notation =5; Cardinality missing or wrong =3; (overall) Number of correct relationships >0 and no extra relationship =2.

Grading Scale for TML Module 2

- **Question 1 (12 points):** (for each of the two fields) field name correct and in the correct row =3; field name correct but in the wrong row =2; table name correct = 1; “show” box checked for the field =2;
- **Question 2 (18 points):** (for each of the two fields) Field name correct =3; Field name correct but in the wrong row =2; Table name correct =1; Criterion has correct sign =1; Criterion value is proper =2; Criterion corresponds to the right field =1; Criterion entered in the “criteria” row =1.
- **Question 3 (10 points):** Field name correct =3; Field name correct but in the wrong row =2; Table name correct =1; Criterion has correct sign =2; Criterion value is proper =2; Criterion corresponds to the right field =1; Criterion entered in the “criteria” row =1.

A7 - Experimental Scripts

A. Welcome Screen

In this training session we will introduce you to Database Technologies via two online e-learning modules. You will play computer games after each learning module based on the material you have learned.....

We have paired you with another undergraduate student (called your competitor) who is going through the same session at a different location and will compete with you in game-playing modules 1 and 2 (but not the practice games). Your competitor is randomly assigned, but will remain the same throughout this session....

The estimated time for today's e-learning session is around 90 minutes. If you finish early, please wait quietly at your seat for the whole session to finish.

B. Instruction for TML Module 1

Next we present you TML Module 1 where you will learn Database Technology through e-learning.

*Remember that after TML Module 1, you will proceed to play the Game Module 1 that is similar to the practice game, but based on content covered in the upcoming TML Module. **Note also that after TML Module 1, you will be playing against your competitor for higher total earnings in Game Module 1.***

C. Instruction for Game Playing

*Remember that in this game-playing module, you will compete against your competitor for higher total earnings. **Each of you will be prompted to play two games in Game Module 1.** During the game play, we **collect performance information in real time** and will periodically show you your competitor's progress. After the module is over, **we will show you and your competitor the result of the competition, including each other's total earnings and the winner of this game playing module.***

D. TML Module 1

This module introduced the basic concepts in database management, including (1) the advantages of the database approach, (2) the definitions of tables, primary keys, and foreign keys, (3) the basic notations of E-R diagrams, and (4) steps to draw an E-R diagram.

E. Message before Game Competition

Please wait on your competitor

Your competitor is not yet ready to play Game Module 1. Please wait a minute or two. While you're waiting, feel free to watch a random YouTube video below (when your competitor is ready, this video will disappear).

F. Competition Results After the First Game Competition⁷

⁷ Note that in the first game competition, each participant played two rounds of the millionaire game using different questions drawn from TML Module 1. Total earnings of the two rounds were used to determine the winner of the competition.

You win!

Your round 1 earnings: \$0

Your round 2 earnings: \$16,000

Your total earnings: \$16,000  **winner**

Your competitor's total earnings: \$2,000

G. Manipulation Check Question

What was the result of your match with your competitor? [Choices - There was no competitor/ I don't know/ I outperformed my competitor/ I tied my competitor/ My competitor outperformed me]

H. TML Module 2

This module covered concepts relating to (1) database management systems, (2) introductions to Microsoft Access, (3) how to place queries in Access, and (4) concepts relating to data warehousing.