

# Using Interactive Flash Games to Enhance Students' Learning in Animal Sciences<sup>1</sup>

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## Abstract

The objective of this paper is to demonstrate how the use of interactive flash games in three animal science courses enhances student learning and comprehension of complex concepts and difficult new material and improves test scores. Flash games were used as companion tools to Feeds and Feeding, Applied Animal Nutrition and Animal Reproduction courses taught at the University of Minnesota, Crookston. The template for flash games was the same for all courses. In two studies, student learning and comprehension of course material were tested. The first study used student final exam scores from the three courses to compare the efficacy of flash games in improving students' test scores with that of commonly used study guides. The exam format for all students was a "mixed exam" containing multiple choice and essay questions. The second study used two courses and two test formats: the "mixed format" as in the first study and an "all multiple choice exam." Scores from two midterms and one final exam were used in this study. In both studies, flash games and study guides covered the same learning material. Exam scores and student surveys clearly supported flash games as an effective technology in improving student comprehension and enhancing learning. In study 1, for all three courses, students' exam scores using flash games were improved by an average of  $16.0 \pm 2.64$  points over study guides. More than 90% of students indicated flash game-assisted instruction contributed to better learning. In study 2, for the two

courses, flash games showed an improvement of student test scores by  $23.7 \pm 1.07$  points over the study guides.

## Introduction

Recent focuses on student-centered approaches have revitalized interest in alternative teaching and learning perspectives (Hannafin and Land, 1997). Several teaching methods are being used in the classroom to enhance student learning. These methods defined by Western Kentucky University's Center for Teaching and Learning (Western Kentucky, 2001) included active learning, critical thinking, problem-based learning, case-based learning, collaborative/cooperative learning, service learning and other instructional types. Flash games teaching is an instructional approach designed to support active, critical thinking and problem-based learning; however, it could be used to support several other types of teaching methods. With the increased volume of information and students' need to process that information in a more meaningful manner, faculty are steadily gaining more interest in exploring different ways to make learning more engaging and enjoyable for students. The rapid proliferation of technology can and will continue to impact the educational paradigm on college campuses (Mehlhorn et al., 2007).

The use of Tablet PC (White et al., 2007), compact discs (Jones et al., 1995), podcasts (Burcham et al., 2007), custom built lock-out buzzers with timers (Headings,

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2007), video tutorials (Musunuru and Beutner, 2007) and class blogs (Spindler, 2007) help create deeper connections with students and a more student centered course context (Spindler, 2007). Jones et al. (1995) indicated that most evaluations of the effectiveness of technology focus on the technology itself, its costs, its complexity and its feasibility in particular circumstances; but they do not examine its effectiveness as a tool for learning. Interactive flash games, built as companion tools to courses, could be an effective technology used to enhance student learning. The objective of this paper is to demonstrate that computer-based interactive flash games used in three animal science courses are effective in enhancing student learning and improving student exam scores over commonly used study guides.

### Material and Methods

Two studies were conducted to compare student exam scores using interactive computer flash games versus commonly used study guides learning methods. One flash game and one study guide was used per exam and per course. One final exam was used in study 1. Two midterms and one final exam were used in study 2. The final exams in each course were cumulative. The two learning methods are described as follow:

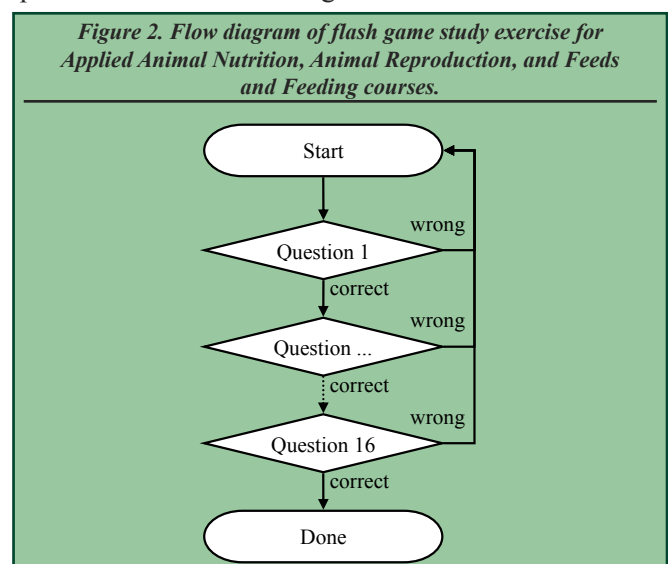
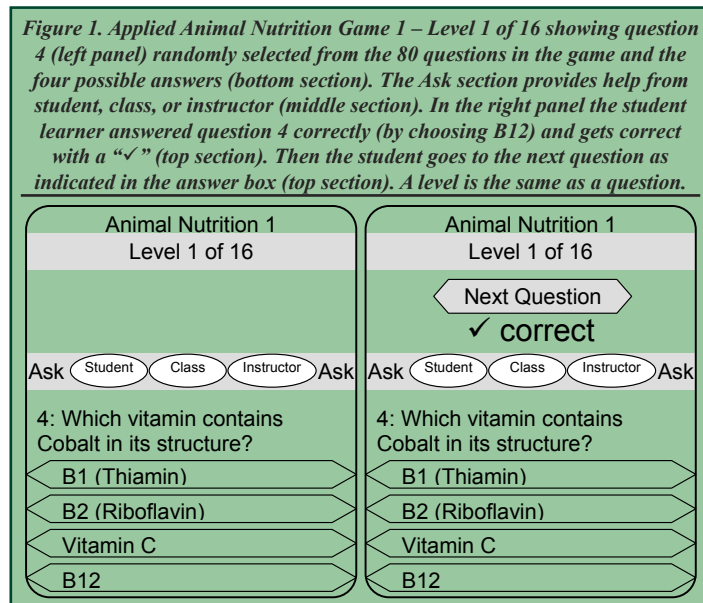
### Interactive Flash Games Study Method

A flash game template was designed by the University of Minnesota, Crookston Information Technology Center (ITC) for faculty use to supply students with questions that would help them learn course material. The template was filled by the instructor with interactive games of multiple choice questions. Games were called flash games because study questions were drawn randomly from a pool of questions like in flash card games. Games

were built as companion tools to Feeds and Feeding (sophomore level), Applied Animal Nutrition (junior-senior level) and Animal Reproduction (junior-senior level) courses.

Questions in a flash game were related to simple and complex concepts or to new terminology and were designed with the choice of four answers for each question. For example in the Applied Animal Nutrition course, a question might ask for the definition of a simple word such as “glycolysis” or a complex concept (e.g., calculating the total energy (ATP) derived from the complete oxidation of a long chain fatty acid in the Krebs’s cycle). A single flash game contains 80 questions drawn from five to six chapters of a course. The interactive template displayed three sections (Figure 1): “Question”, “Ask” and “Answer.” Multiple choice questions were fed into the question section (bottom section of the figure 1). The “ask” section was a help section (middle section of the figure 1) that provided support to an individual student to learn collaboratively by interacting with the instructor, classmates or another student. Students used the “ask” section to ask for help when they did not know or doubted an answer to a question. In case of doubt, they had the option to ask the opinion of either “the Instructor” or “the Class” or “a Student” in the classroom. The instructor always gave the correct answer to a question (100% right and 0% wrong).

Answers provided by the class as a group of students were programmed to be 75% right and 25% wrong and answers provided by a random single student were programmed to be 50% right and 50% wrong. The ratios of right versus wrong answer from the help section were initially set in the template by the ITC in order to make the games more interactive. The answer section of the figure displayed the response (correct or wrong) to the question. For time management and effective active



## Using Interactive Flash Games

learning, questions were played in a group of 16 questions (or levels) with the degree of difficulty increasing with each question. The initial question was drawn randomly from the pool of 80 questions. Each successive question became more difficult and was selected randomly from the remaining questions in the pool. In order to proceed to the next question, the student learner had to successfully answer the previous question. A wrong answer to any of the 16 questions automatically stops the game and the learner was prompted to start a new game (Figure 2).

Students could stop the game at any time by closing the window. The course instructor's assistance was not required for students to be able to use and learn from the flash games. For learning to occur students were encouraged to reflect upon each question and explain to themselves why their answers were correct or incorrect. Also, they were encouraged to learn collaboratively by interacting with the "ask" section of the game; however, they could query the instructor, the class and students only one time per group of 16 questions. On average, it took three to four hours of continuous active learning for students to fully master one game. Each course had three or four games, depending on course content, which made a total of 240 or 320 questions for a course. Flash games were introduced in the three courses in different years. Applied Animal Nutrition and Animal Reproduction were the first courses to integrate the games.

### Study Guides Method

Each course was supplemented with a study guide containing no less than 30 short and long essay questions designed to cover the same chapters as the flash games for an exam. This was done to minimize the effect of course material difficulty on the experimental error which would occur if two different sets of materials were used. The following four questions illustrate the types of questions for a study guide in the Feeds and Feeding and Animal Reproduction courses:

1. List morphological and nutrient content differences between a forage legume and a forage grass (short answer for Feeds and Feeding).
2. Discuss nitrate poisoning, prussic acid poisoning and grass tetany in cattle (long answer in Feeds and Feeding).
3. Define these terms: reproductive physiology andrology, gynecology, theriogenology and obstetrics (short answer in Animal Reproduction).
4. Draw and explain positive and negative hormonal feedback mechanisms (long answer in Animal Reproduction).

Questions on all exams were slightly modified from the questions in flash games and study guides. This adjustment was made to ensure that students were not

just memorizing the information. Although questions on study guides and flash games covered the same material, questions on exams based on these two study methods, were different. For example in the Animal Nutrition course, a study guide question worth 10 points for lipid and fatty acids properties might be: discuss the physical properties of fatty acids, solubility in water, melting point, degree of saturation, susceptibility to oxidation, iodine number and saponification number. Whereas the flash game might include five multiple choice questions on lipid and fatty acids worth 2 points each asking the following questions: where is an ester bond found; which fatty acid is an omega-3; which fatty acid is not essential; which fatty acid is unsaturated; and what are the components of a triglyceride with each question having four answer choices.

### Data collection and Learning Assessment

In two studies, student learning and comprehension of the course material were tested. In the first study, student grade reports were used to collect final exam scores data of 95 students enrolled in Applied Animal Nutrition course (ANSC 3104) from 2003 to 2007, 58 students in Feeds and Feeding (ANSC 2104) from 2006 and 2007 and 64 students in Animal Reproduction (ANSC 3304) in 2003, 2006 and 2007. Student school identification numbers were used to gather the data; therefore, student names were not part of the process. The data was used to compare students' performance based on using flash games and study guides as supporting materials for the courses but also considered as study methods for the course material. All three courses were taught by the same instructor and exams were administered in the same classroom for all years. Animal Reproduction was taught by another instructor in 2004 and 2005; therefore, scores for these years were not included in the data.

In the first study, only the final cumulative exam was used. Students had three to four flash games and three to four study guides to use as study tools for the final exam. Exams consisted of two sets of questions and were scored on 200 points. The first set of questions, drawn from flash games, made up one half of the exam points (100 points) and the second set, drawn from course study guides, made up the other half of the points (100 points). The questions for both sets of the exam were balanced to measure student scores based on the two learning methods. All students were tested on both sets of questions and their scores for the set from the flash games were compared to the scores of the set from the study guides. This statistical design used a student as his/her own control; therefore, the error from the experimental unit was removed.

At the completion of each course in 2006 and 2007, students filled out a survey of their own perception about using and learning from flash games. The survey did not include the study guide learning method because the instructor had already integrated this learning approach into all of these courses prior to the introduction of the flash games; therefore, study guides were the control learning method against which flash games were compared.

In the second study, exam scores of 93 students enrolled in Feeds and Feeding (ANSC 2104) and 53 students in Applied Animal Nutrition (ANSC 3104) were collected in 2010 and 2011. The data was used to compare student test score performance based on the two study methods (flash games versus study guides) and two exams formats (an all multiple choice exam versus a mixed exam). One flash game and one study guide was available to study from for each exam. The all multiple choice exam (AMC) had two sets of questions; the first set of 50 questions was drawn from the flash games and second set of 50 questions drawn from the study guides for a total of 100 points for the exam.

The mixed exam (MIX) weighted on 100 points also had two sets of questions, the first set of questions drawn from the flash game contained 50 multiple choices questions worth 50 points and the second set, drawn from the study guides contained 10 to 12 short and long essay questions worth 50 points. During each year and for each course, students had two midterms (exam 1 and 2) and one cumulative final exam (exam 3). Students had the absolute choice to take the exam format they desired. They signed a consent form to take the exam and did not agree to take a random exam (either AMC or MIX). They feared a random exam would not allow them to use their testing skills to obtain a good grade.

**Statistical Analysis**

Data was analyzed with a generalized least squares method (mixed procedure of SAS; Littell et al., 1996). In the first study, fixed effects included in the model were study method, year and the interaction of study method x year. In the second study, the model included the study method, the exam format and the interaction of study method x exam format.

**Results and Discussion**

**Study 1**

The means of final exam scores (200 points) for the three courses are reported in Table 1. Students usually had higher average scores in Feeds and Feeding, intermediate scores in Animal Reproduction and lower scores in Applied Animal Nutrition. Applied Animal Nutrition integrated more biochemical

and mathematical concepts to economical feeding of farm animals; therefore, tended to be more challenging to students than the other two courses. Differences between courses might also be due to the fact that different students were evaluated in the three courses over the different years as shown by the interaction study method x year for the Animal Applied Nutrition and Animal Reproduction (Table 3).

The contribution of flash games (100 points) versus study guides (100 points) to the means scores within courses is reported in Table 2. For all three courses, student average scores for flash games were higher ( $P < 0.01$ ) than those for study guides. Differences of means are also shown in Table 2. For all three courses, there was an average of  $16.0 \pm 2.64$  points advantage of flash games over study guides. Within courses, there were  $15.3 \pm 3.09$  points,  $19.3 \pm 2.42$  points and  $13.4 \pm 2.95$  points advantage of flash games over study guides for Feeds and Feeding, Applied Animal Nutrition and Animal Reproduction, respectively. Bloom and Hough (2003) reported that computer-based learning across elementary, secondary, higher and adult education programs increased students' test scores by 10 to 20 percentile points. Jeffries (2001) also found a significantly higher knowledge level of students using an interactive multimedia CD-ROM in a nursing course than students who did not use the CD-ROM. The impact of flash games on students' scores was more dramatic in Applied Animal Nutrition (the course with the lowest grades) indicating that flash games could be highly beneficial to enhancing student learning in courses with difficult concepts. However, for all courses, flash games were shown to be helpful to students to learn the course material and improve their final exam scores.

*Table 1. Least Squares Means of Final Exams Scores (over 200 points) for Feeds and Feeding (ANSC 2104) in 2006 and 2007, Applied Animal Nutrition (ANSC 3104) in 2003 through 2007, and Animal Reproduction (ANSC 3304) in 2003, 2006 and 2007*

Course	N <sup>1</sup>	Score, LSMEAN <sup>2</sup>	SEM <sup>3</sup>
ANSC 2104	58	165.36	3.98
ANSC 3104	95	131.98	2.42
ANSC 3304	64	147.40	3.56

<sup>1</sup>Number of students in each course  
<sup>2</sup>Least squares mean over 200 points  
<sup>3</sup>Standard error of the mean

*Table 2. Least Squares Means and Means differences of Final Exams Scores for flash games (over 100 points) versus study guide methods (over 100 points) for Feeds and Feeding (ANSC 2104) in 2006 and 2007, Applied Animal Nutrition (ANSC 3104) in 2003 through 2007, and Animal Reproduction (ANSC 3304) in 2003, 2006 and 2007*

Course	N <sup>1</sup>	Method		SEM <sup>2</sup>	P	Diff <sup>3</sup>	SED <sup>4</sup>	P
		Flash	Study					
ANSC 2104	58	90.32	75.04	2.52	<0.01	15.28	3.09	<0.001
ANSC 3104	95	75.65	56.32	1.72	<0.01	19.34	2.42	<0.001
ANSC 3304	64	80.4	67.00	2.31	<0.01	13.41	2.95	<0.001

<sup>1</sup>Number of students in each course  
<sup>2</sup>Standard error of the mean  
<sup>3</sup>Least squares mean differences  
<sup>4</sup>Standard error of mean differences

## Using Interactive Flash Games

The advantage of flash games over study guides was observed over multiple years for each course (Table 3). Method of studying material was always significant ( $P < 0.001$ ) for all three courses. The year the exam was taken had no significant effect on how students scored on exams, except for Applied Animal Nutrition ( $P = 0.05$ ). However, the interaction between method and year was significant ( $P < 0.001$ ) for Applied Animal Nutrition and Animal Reproduction courses (Table 3). Flash games were introduced first in these two courses in 2003. When flash games were introduced to students they did not use them much to study, because they did not know the value of the games. In fact, because students did not know the value of using flash games the first year (2003), their exam scores for the two methods were not different ( $P \geq 0.47$ ) in Applied Animal Nutrition and Animal Reproduction. As students became familiar with the games and learned how helpful they were to study, the word spread among students in subsequent years. In 2004, flash games tended to improve ( $P = 0.07$ ) scores by 11.7 points but in 2005 scores were again not different ( $P = 0.18$ ) for Applied Animal Nutrition (Table 3).

By 2006, scores for the two methods were significantly different ( $P < 0.001$ ) in all courses with higher scores for the flash game method. The advantage of flash games over study guides could be explained by factors such as more precise presentation of the information, less wording, less memorization, highly visual and more time exposure to the same information. It also appears students prefer using flash games over study guides in Applied Animal Nutrition, because scores have decreased over the years (except in 2005) for the study guides method whereas scores tended to increase with the flash game method.

Student response to their perception about flash games as learning tools is shown in Table 4. The survey showed that the majority of students (87% or more) for all three courses agreed or strongly agreed with the following statements:

1. Flash games helped me study for exams.
2. Flash games helped me learn course material.
3. Flash games helped me improve my test scores.
4. Flash games are effective technology enhanced learning tools.
5. I believe flash game-assisted instruction contributed to better learning.

Response of students to statement 5 above is similar to student perception about technology assisted instruction reported by Burris and Doerfert (2007) and Bloom and Hough (2003). Daley et al. (2001) also found that students' attitudes and perceptions

**Table 3. Effect of method of studying (Flash games versus Study guides) within courses on final exam scores per year**

Course/Year	Method			Probability		
	Flash	Study	SEM <sup>1</sup>	Method	Year	Method*Year
<b>ANSC 2104</b>				<b>&lt; 0.001</b>	<b>0.53</b>	<b>0.51</b>
2006	90.2	73.6	2.2	<0.001		
2007	87.3	73.6	2.3	<0.001		
<b>ANSC 3104</b>				<b>&lt; 0.001</b>	<b>0.05</b>	<b>&lt; 0.001</b>
2003	73.8	69.1	4.6	0.47		
2004	67.2	55.4	4.6	0.07		
2005	74.9	66.4	4.4	0.18		
2006	74.1	47.8	4.7	<0.001		
2007	83.7	47.3	3.6	<0.001		
<b>ANSC 3304</b>				<b>&lt; 0.001</b>	<b>0.28</b>	<b>&lt; 0.001</b>
2003	73.0	75.3	3.1	0.60		
2006	83.5	58.3	3.2	<0.001		
2007	84.5	66.8	2.9	<0.001		

<sup>1</sup>Standard error of the mean

**Table 4. Summative perception of students from surveys completed in 2006 and 2007 about flash games as learning tools in three courses: Feeds and Feeding (ANSC 2104); Applied Animal Nutrition (ANSC 3104); and Animal Reproduction (ANSC 3304)<sup>1</sup>**

Question	Course	Response, %				
		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Flash games helped me study for exams?						
	2104	73	27	--	--	--
	3104	60	40	--	--	--
	3304	70	30	--	--	--
Flash games helped me learn course material?						
	2104	71	29	--	--	--
	3104	35	52	13	--	--
	3304	51	44	5	--	--
Flash games helped me improve my test scores?						
	2104	85	15	--	--	--
	3104	60	35	5	--	--
	3304	79	16	5	--	--
Flash games are more helpful to study and comprehend the information than the study guides that cover the same material?						
	2104	44	15	41	--	--
	3104	35	26	39	--	--
	3304	30	35	30	5	--
Based on course content, I think some flash game questions are harder than others?						
	2104	15	61	0	24	--
	3104	30	58	12	--	--
	3304	25	65	5	5	--
In general, I think flash games are effective technology enhanced learning tools.						
	2104	71	29	--	--	--
	3104	49	42	9	--	--
	3304	44	56	--	--	--
I think flash games should be introduced in other UMC courses?						
	2104	56	44	--	--	--
	3104	42	44	14	--	--
	3304	56	39	5	--	--
In general, do you believe flash games-assisted instruction contributed to better learning?						
	2104	56	44	--	--	--
	3104	44	47	9	--	--
	3304	60	35	5	--	--

<sup>1</sup>Number of students who completed the survey for ANSC 2104 was 41; ANSC 3104 was 43; and ANSC 3304 was 43.

of technology influenced their ability to acquire and integrate knowledge, extend and refine knowledge and use knowledge meaningfully.

The survey also showed that 100% of students in all courses recommended using flash games as companion instructional tools to these courses (data not shown). Based on course content, the majority of students (76 to 88%) thought some flash game questions were harder than others. When comparing flash games with study

guides as learning tools for all courses, 59% to 65% of students indicated that flash games were more helpful to study and comprehend the information than study guides that covered the same course material; 30% to 41% of students were neutral and 5% disagreed with this statement (Table 4). Students who were neutral or disagreed thought that study guides were also helpful and that they were complementary to the flash games in facilitating learning. This statement implies that when students were exposed to similar course information, there could be an associative effect of learning methods which would be difficult to separate statistically.

Testing student learning with two different course materials would not have been conclusive. This is because of the error that would be introduced in the data by the differences in materials which could include degree of difficulty and student interest in the material. Jones et al. (1995) pointed out that student learning could not be solely defined by how well students performed on standardized tests but also by the extent to which technology promoted students engaged learning and collaboration. More than 90% of students indicated flash game-assisted instruction contributed to better learning.

**Study 2**

The means of the three exam scores for flash games and study guides within exam formats (AMC versus MIX) for the two courses are reported in Table 5. Similar to the first study, study method is also significant in this second study ( $P < 0.0001$ ) for both courses and the three exams. The mean scores for flash games were higher than those of study guides for Feed and Feeding (88.3 versus 66.8 points) with a mean difference of  $21.5 \pm 1.24$  (Table 6) and for Applied Animal Nutrition (76.6 versus 50.3 points) with a mean difference of  $26.3 \pm 1.84$  (Table 7). This second study confirmed the learning advantage of the computer-based flash games over the common essay-type study guides. This finding is also in agreement with data reported by Bloom and Hough (2003) and Jeffries (2001).

The exam format was significant ( $P < 0.0001$ ) for the Feeds and Feeding course but not for the Applied

**Table 5. Least squares means of flash games and study guides within exam format for Feeds and Feeding (ANSC 2104) and Applied Animal Nutrition (ANSC 3104) for the combined two years**

ANSC 2104												
Exam	Flash			Study			Year	Format	Method	Format x Method		
	N <sup>3</sup>	AMC <sup>1</sup>		N <sup>3</sup>	MIX <sup>2</sup>							
		Mean <sup>4</sup>	SEM <sup>5</sup>		Mean <sup>4</sup>	SEM <sup>5</sup>						
1	77	84	53	1.5	16	91	76	3.3	0.126	<.0001	<.0001	0.0024
2	64	85	61	1.6	23	93	76	2.3	0.351	<.0001	<.0001	0.0374
3	61	85	51	1.4	21	90	82	2.5	0.006	<.0001	<.0001	<.0001

ANSC 3104												
Exam	Flash			Study			Year	Format	Method	Format x Method		
	N <sup>3</sup>	AMC <sup>1</sup>		N <sup>3</sup>	MIX <sup>2</sup>							
		Mean <sup>4</sup>	SEM <sup>5</sup>		Mean <sup>4</sup>	SEM <sup>5</sup>						
1	43	81	50	2.3	10	85	62	5.1	0.721	0.0569	<.0001	0.2911
2	28	78	46	3.2	24	75	52	3.4	0.916	0.7059	<.0001	0.153
3	27	68	45	2.9	23	75	48	3.1	0.024	0.1039	<.0001	0.5495

<sup>1</sup>All multiple choice exam

<sup>2</sup>Mix exam (multiple choice and essay questions)

<sup>3</sup>Number of students who took the exam (i.e., for ANSC 2104: Exam 1, 77 students took AMC exam, and 16 students took MIX exam. For AMC and Mix, questions were based on flash game and study guide)

<sup>4</sup>Mean in percent for exam questions based on flash game and study guide

<sup>5</sup>Standard error of the mean

**Table 6. Means and Differences of Means of Three Exam Scores for Feeds & Feeding (ANSC 2104)**

Effect	Exam Format	Study Method	LS <sup>1</sup> Means	SEM <sup>2</sup>
Method		Flash	88.3	0.89
Method		Study	66.8	0.89
Format	AMC		70.3	0.63
Format	MIX		84.7	1.11
Format x Method	AMC	Flash	84.9	0.89
Format x Method	AMC	Study	55.7	0.89
Format x Method	MIX	Flash	91.7	1.54
Format x Method	MIX	Study	77.9	1.54

Effect	Exam Format	Study Method	Exam Format	Study Method	Means Diff <sup>3</sup>	SED <sup>4</sup>	P
Method		Flash		Study	21.5	1.24	<0.001
Format	AMC		MIX		-14.4	1.27	<0.001
Format x Method	AMC	Flash	AMC	Study	29.2	1.25	<0.001
Format x Method	AMC	Flash	MIX	Flash	-6.6	1.77	<0.001
Format x Method	AMC	Flash	MIX	Study	7.0	1.77	<0.001
Format x Method	AMC	Study	MIX	Flash	-35.8	1.77	<0.001
Format x Method	AMC	Study	MIX	Study	-22.2	1.77	<0.001
Format x Method	MIX	Flash	MIX	Flash	13.7	2.33	<0.001

<sup>1</sup>Least squares means

<sup>2</sup>Standard error of the mean

<sup>3</sup>Means difference

<sup>4</sup>Standard error of the mean difference

Nutrition course ( $P > 0.05$ ) (Table 5). Students who chose the AMC exam scored significantly lower than those who chose the MIX exam in Feeds and Feeding (70.3 versus 84.7 points) with a mean difference of  $(-14.4 \pm 1.27)$  (Table 6). For the Applied Animal Nutrition course, there was no difference ( $P > 0.05$ ) in the mean score based on exam format; however, student who chose the MIX exam had  $4.8 \pm 1.92$  points advantage over those who chose the AMC exam (Table 7). There was a significant exam format x study method interaction for the three exams in the Feeds and Feeding ( $P < 0.04$ ) course, but the interaction was not significant for the Applied Animal Nutrition course ( $P > 0.15$ ) (Table 5) with the separation of mean differences reported in Tables 6 and 7.

## Conclusions

Interactive flash games are technology-enhanced tools that can be used to improve classroom teaching and student learning. They are individual student learner-centered and allow for interactive collaborative learning. The instructor's assistance is not required for individual student learning to occur. In the first study, for all three courses, student exam scores improved by an average of  $16.0 \pm 2.64$  points using flash games over study guides. In the second study, the flash game study method had a  $21.5 \pm 1.24$  points for Feeds and Feeding,  $26.3 \pm 1.84$  points for Applied Animal Nutrition and an average of  $23.7 \pm 1.07$  points advantage for both courses over the study guides. Students did better with a mixed exam format than with an all multiple choice exam. The MIX exam had  $14.4 \pm 1.27$  points for Feeds and Feeding,  $4.8 \pm 1.92$  for Applied Animal Nutrition and an average of  $10.4 \pm 1.09$  points advantage for both courses over the AMC exam.

In conclusion, student final exam scores and the learning perception survey showed that flash games are effective tools in enhancing student learning and improving the exam average score over more commonly used study guides. More than 90% of students indicated flash game-assisted instruction contributed to better learning. The flash game template can be easily adapted to various courses. Further studies including randomization of student assignment to exam model, the effect of actual student time spent studying the material from flash games and study guides on exam scores, a comparison of traditional instructor-led study groups with the flash games and testing flash game model on larger universities are warranted.

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*Table 7. Means and Differences of Means of Three Exam Scores for Applied Animal Nutrition (ANSC 3104)*

Effect	Exam Format	Study Method	LS <sup>1</sup> Means	SEM <sup>2</sup>			
Method		Flash	76.6	1.30			
Method		Study	50.3	1.30			
Format	AMC		61.1	1.14			
Format	MIX		65.7	1.50			
Format x Method	AMC	Flash	75.4	1.60			
Format x Method	AMC	Study	46.8	1.60			
Format x Method	MIX	Flash	77.8	2.09			
Format x Method	MIX	Study	53.9	2.09			
Effect	Exam Format	Study Method	Exam Format	Study Method	Means Diff <sup>3</sup>	SED <sup>4</sup>	P
Method		Flash		Study	26.3	1.84	<.001
Format	AMC		MIX		-4.8	1.92	<.001
Format x Method	AMC	Flash	AMC	Study	28.6	2.24	<.001
Format x Method	AMC	Flash	MIX	Flash	-2.4	2.66	<.001
Format x Method	AMC	Flash	MIX	Study	21.5	2.66	<.001
Format x Method	AMC	Study	MIX	Flash	-31.0	2.66	<.001
Format x Method	AMC	Study	MIX	Study	-7.2	2.66	<.001
Format x Method	MIX	Flash	MIX	Flash	23.9	2.93	<.001

<sup>1</sup>Least squares means  
<sup>2</sup>Standard error of the mean  
<sup>3</sup>Means difference  
<sup>4</sup>Standard error of the mean difference

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