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Knowledge Retention over a Two Year Period Following Completion of
an Online Course on The Science of Energy Balance

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Abstract

Objective: To evaluate knowledge retention among students who had taken an online Science of Energy Balance course over a one to two year follow up period.

Design: This study used a validated knowledge assessment from the online course The Science of Energy Balance. The assessment was delivered using LimeSurvey. The data were analyzed using MS Excel.

Setting: This study was conducted at the University of Vermont.

Participants: Twenty-three students who had previously taken the online Science of Energy Balance course were recruited as study participants. Ten students who had never taken a nutrition course were recruited as control participants.

Intervention(s): Participants were asked to complete an online validated knowledge assessment.

Main Outcome Measure(s): Original scores act as the covariant and the newest scores are the dependent variable. All scores were calculated out of a maximum score of 25.

Analysis: Two experimental group differences were analyzed using ANCOVA. T-tests were performed to analyze experimental group scores against control group scores as well as experimental group original scores against new scores.

Results: There was no significant difference between experimental group new scores and the control group new scores. There was no significant difference between the new scores of 1 year and 2 year post course. The pooled experimental group had a significant decrease from old score to new score.

Conclusions and Implications: Due to the small sample size and the unexpectedly high control group mean scores, we were not able to show a significant knowledge retention among students who had previously taken the online Science of Energy Balance.

Introduction

Online learning has become increasingly popular since the start of the internet (1). Online courses refer to courses where 100% of the course material is presented in an online format. As of 2013, 32% of students, or roughly 6.7 million students indicated that they have taken at least one course online (2). The first online courses began in 1981, as mini executive training programs (3). Today, not only can you take online college courses as part of your degree requirements, but now higher education institutions offer degree programs that are completely online. In 2002, 34% of colleges offered entire degree programs online. This percentage increased to 62.4% in 2012 (2). There has been an annual growth rate of students taking online courses of 17.3%, whereas there has only been a 2.6% growth rate for students taking courses in total (4).

There are many reasons for such a dramatic increase in the amount of students enrolled in online courses. One of the reasons is that there are hundreds of online course offerings. Many universities see online courses as an additional way to generate revenue. Revenue increases because universities are able to enroll more students while utilizing less concrete resources (classrooms, paper, etc.) (1, 5, 6). Universities see online courses as a way to improve student access to education (1, 5). Many universities have started to participate in massive open online courses (MOOC's), where hundreds of thousands of students worldwide can enroll in an online college course. The benefits of these massive open online courses are that they are less expensive for students than a traditional classroom. Since 1985, there has been a 559% increase in the cost of college education (7). With this continuous growth, not everyone can afford a traditional college education. However, the majority of our population can afford a computer. The expansion of online learning gives hope that anyone anywhere will be able to be a lifelong learner (7).

Online learning offers many advantages. The most cited advantage of online education is student flexibility (5, 8, 9, 10, 11). All a student needs is a computer and internet connection to participate in an online course. Students no longer need to commute to a campus. Students can take their online courses around their own schedules. Being able to do school work around one's own schedule can be crucial when it comes to someone who has a family or works a full time job (5, 9, 10). Not only can students work around their schedules, but they can also work at their own pace. Students can make their own school hours and they have the ability to review lectures and go over material as much as they would like (6, 8).

In a study by Kroncke (2010) looking at a comparison between online versus traditional laboratory experiments, students noted that they appreciated being able to repeat the online experiment continuously if they wanted to review important steps (12). Students may also be able to take online courses from prestigious universities that they may not have been able to "attend" before, as many of these courses are open to continuing education students (13).

Another advantage of online learning is that the student is forced to become independent. Being independent in one's studies enables skills such as critical thinking and problem solving (14). Online students are more likely participate in the course, unlike in a traditional classroom where a few students may do the majority of the participation while others are passively learning (6). Students who benefit from individual learning and feel comfortable with indirect contact with an instructor may benefit from these courses. Students may come across tough material in their studies and since a professor may be unable to give immediate feedback, students are able to spend more time working through problems on their own to find the answer (6). By going through problems on one's own there is a higher likelihood of remembering how to get to the answer (6).

Although the lack of instructor presence may allow a student to work through problems on their own and decrease anxiety, a disadvantage of online learning is the lack of instructor presence (3, 10, 14). Online learning lacks immediate explanation, clarification, and nonverbal clues that a student may find helpful in the traditional classroom setting (10). Students may feel isolated, which may weaken their communication skills (8, 14). The lack of instructor presence is also seen as a disadvantage of online learning when discussing academic integrity in the online classroom. Since there is no professor proctoring exams, students may choose to violate academic integrity rules by using their notes or the internet to help them pass (10, 15).

Another disadvantage of online learning may be technical difficulties and confusion related to the online program (3). Students may become flustered by confusing sites (3). Students may also become flustered by the increased amount of effort that goes into an online course. Although flexibility is an advantage of online learning, a student's lack of time management skills may be a disadvantage (10).

Regardless of the advantages and disadvantages to online learning, the majority of academic leaders believe that online courses are comparable with traditional courses (2). Knowledge gain from traditional courses and online courses are typically equal. Studies looking at differences in knowledge gain between traditional and online courses tend to use pre-test and post-test analysis to see a change over time. There have been online knowledge gain studies in many different academic disciplines. These disciplines range from sociology and statistics to medicine and nutrition. The majority of these studies conclude that there is no significant difference in knowledge gain between an online course and a traditional classroom course (5, 6, 9, 10, 15).

In a systematic review by Cohen et al (2011) of online nutrition courses they focused on

nine different studies using online education (16). They found that students gain knowledge just as well using an online course as a traditional classroom course. However, many of the studies that Cohen et al., looked at were quasi experiments or theoretical models which may have altered the results.

Online courses have also been used as gateways to behavior change. Aboul-Enein et al (2014) used an online course educating students on the health benefits of the Mediterranean diet. By using surveys to generate pre and post course means scores, they found that the online course caused students to change eating behavior (4).

Ha et al (2009) used a 3 day pre and post analysis of a 3 day food record on students in a traditional nutrition course (17). They were looking to see whether or not a nutrition class explaining the benefits of eating fruits and vegetables, and the risks and diseases associated with deficiencies, would influence people's decisions to eat more fruits and vegetables. They found that, compared to the pre 3 day analysis, people added more fruits and vegetables to their diet by the end of the course.

The study by Franco et al (2008) looked at college students who were taking an online nutrition class (18). They tested the change in lifestyle, education, motivation, and self-efficacy by using an online nutrition education website on many different campuses. This website included nutrition and physical activity education for college students as well as questionnaires for the study which included: food frequency, stages of dietary and physical activity change, nutrition knowledge test, physical activity, social support, and exercise benefits/ barriers. They found that after the course there was a greater nutritional lifestyle change.

An additional area of online learning research looks at knowledge retention from online courses compared to traditional courses. The outcomes of research studies focusing on

differences in knowledge retention are mixed. While some studies found that there was no statistical difference in knowledge retention between the two modalities (9, 14), others found that the online courses had higher knowledge retention rates (12, 19). These studies suggested that the differences (or lack of difference) may be due to the type of information being presented. For example, the type of information from an English or sociology course is much less hands on than a statistics or biology course.

For example, Schardt et al (2007) looked at the knowledge retention rate of medical librarians after taking the Evidence-Based Medicine online course compared to the traditional classroom version. They found that there was no significant difference between the two modalities (9). On the other hand, Gallagher et al (2005) studied the knowledge retention rates of students taking a course on gerontology. They found that online learners had a higher retention rate than those who took the course in the traditional classroom (19).

The differences in these studies may be related to the student's previous knowledge of the topic or exposure to the subject (19). Naidr et al (2010) found that knowledge retention of an online course had a significant correlation with student's positive feedback of the course and the amount of time the student spent on a computer per week (8).

Although there has been research done on behavior change related to online nutrition education and there has been research on nutritional knowledge gain from online courses versus traditional courses, there is limited research on knowledge retention from an online course in nutrition. Nutrition has become an increasingly important subject in today's world. Many students look to increase their knowledge of nutrition and make nutritional changes that may enhance their lifestyle. Since the majority of students access the internet daily, online nutrition education can empower students to access nutritional information at any time (20).

Our research focused on the specific aspect of nutritional energy balance knowledge retention from an online course. The course entitled The Science of Energy Balance is an online one credit course offered at the University of Vermont that covers nutrition energy intake, expenditure, and balance. A previous study on students who had taken this online course by Eisenhardt found that there was a significant increase in energy balance knowledge (21). However, this study did not follow up on one to two year knowledge retention in these students. Considering the studies previously mentioned, the increasing importance of nutrition education, and lack of research in nutrition knowledge retention, our hypothesis was that students who have previously taken The Science of Energy Balance online nutrition course (6-24 months ago) will have a greater knowledge of energy balance than students who have not taken a nutrition course. We further hypothesized that there will not be a significant drop in knowledge from 6-24 months after completing the course. There were two objectives of this study. The first was to compare knowledge assessment scores between students who had previously taken the Science of Energy Balance online course versus a control group of students who have not taken any nutrition courses. The second objective was to measure the change in knowledge assessment scores over time, among students who had taken the Science of Energy Balance online course six, twelve, eighteen and twenty-four months ago.

Methods

The study protocol was reviewed and approved as an exempt study by the University of Vermont Committee on Human Research in the Behavior Sciences on November 11th, 2014. The current study used the same validated knowledge assessment instrument from the prior study of Eisenhardt (7) to determine knowledge retention of students who had previously taken The

Science of Energy Balance online nutrition course. The validated knowledge assessment instrument also determined whether previous Science of Energy Balance students were more knowledgeable of energy balance information than people who had never taken a course in nutrition. The validated knowledge assessment consisted of 25 multiple choice questions which reflected the learning objectives of the course The Science of Energy Balance. The knowledge assessment instrument was delivered through the University of Vermont LimeSurvey program.

Students who had previously taken the online Science of Energy Balance course were recruited for follow-up knowledge assessment for this study as the experimental group. The student email addresses from previous semesters of The Science of Energy Balance were gathered from class rosters. The control participants in this study were students, faculty, or community members who had never taken a course in nutrition and were over 18 years of age. The control group was recruited through flyers placed around the University of Vermont in central locations such as the student center and the library. All experimental and control participants were contacted through email. The email contained a summary of the research being conducted with a research information sheet, and information regarding a monetary incentive for participating in this study. By clicking on the survey link in the email, the participant gave their consent to participate in the research study. Experimental group participants also consented to allow us to access their knowledge assessment scores from when they originally completed The Science of Energy Balance online course. The compensation for participating in this research study was in the form of a raffle. The raffle was for a \$100 Amazon gift card. One gift card was rewarded for every 25 study participants.

After participants had completed the follow-up knowledge assessment, the data were saved in the LimeSurvey database and exported into an MS Excel spreadsheet. Data were

excluded if the assessment was not fully completed by the participant or if there was an unsuitable control participant (ex: under the age of 18 or had previously taken a course in nutrition). In one instance of an experimental participant taking the survey more than once, their scores were averaged to one score for analysis.

A sample size power calculation was performed based on being able to detect a possible 10% decrease in knowledge scores from initial testing to six months follow-up. It was also based on a 5% decrease from subsequent follow up scores (12, 18, and 24 months). Based on the within-group standard deviation of 12 for students who took the original knowledge assessment, we were able to determine that we would need 14 participants per group (6, 12, 18, and 24 months) to obtain a power of 80% at a P value of 0.05. A sample size power calculation was also performed for the control group assuming that there would be a 20% difference between controls and previous students. Based on a within-group standard deviation of 12, seven control participants were needed to have a power of 80% at a P value of 0.05.

Results

There were a total of 54 responses to the validated knowledge assessment survey. Of the 54 responses, only 33 participants had completed the entire assessment and were therefore used in the analysis. Of the 33 participants 23 were in the experimental group and 10 were in the control group. Of the pooled experimental group, 22 were female and one was male. The ages ranged from 19-30 years old. The majority of the majors were science-based (animal science, biochemistry, biology, microbiology, neuroscience, nursing, etc.). Of the control group, five were male and five were female. The ages ranged from 20- 38 years old. The majors were also predominately science based.

Of the 23 total participants in the experimental group, two were from the fall of 2012 class, 10 from winter 2013, two from summer 2013, one from fall 2013, and eight from winter 2014. Since the samples were not large enough to have four distinct time period groupings, the participants were pooled into two groups; those who took the course approximately one year ago, and those who took the class approximately two years ago. The participants from the fall 2012 class were pooled with students from the winter 2013 class as the “two year” period group and all other experimental participants were placed in the “one year” period group.

The results for all group knowledge assessments are presented in Table 1. The mean score for the two year experimental group time period was 18.0 and the mean score for the one year experimental group time period was 16.7 (Table 1). All scores are presented based on a maximum score of 25 out of 25. After running an analysis of covariance on the scores, there was no significant difference in the new scores between the two time periods ($P=0.461$).

A t- test was performed to compare the new experimental group scores to the control group scores. For this analysis, we pooled all 23 participants from the experimental group. The pooled experimental group new mean was 17.4 and the control groups mean score was 20.0 (Table 1). There was no significant difference between these mean scores ($P=0.092$). Since our control group mean score of 20 seemed unexpectedly high, we decided to run a second t- test comparing our pooled experimental group mean score (17.4), versus the mean score of 14.6 for the control group scores that were obtained from students who participated as control subjects in the original study of Eisenhardt (21). There was no significant difference between these mean scores ($P=0.093$).

Finally, in order to determine if there was a significant drop in knowledge retention from the time the students initially completed the course, to our current follow-up knowledge

assessment, a t-test was performed to compare our pooled experimental knowledge assessment scores to the knowledge assessment scores of the same students immediately after they completed the course (1-2 years ago). We found a significant ($P < 0.001$) drop in scores from a mean of 22.1, immediately after completing the course, to a mean of 17.4 at a 1-2 year follow up.

Discussion

The results of this study do not support our original hypotheses. We found no significant difference between the new experimental group mean scores and the control group's mean scores, contrary to our hypothesis that students who had previously taken The Science of Energy Balance online nutrition course would have a greater knowledge of energy balance than students who had not taken a nutrition course. In addition, our results do not support our hypothesis that there would be no significant drop in scores from the scores obtained immediately after completing the course, to our follow up assessments 1-2 years later. Part of the reason why there was a significant drop in scores may have been that students did not take the follow-up assessment seriously. There were a few extremely low scoring participants (<50%) in the follow-up assessment. However there were no low scoring participants during the assessment immediately after the completion of the course. This suggests that the extremely low scoring participants may have guessed through the knowledge assessment.

The results of this study contradict a study done by Eugene Custers (2010) who looked at the knowledge retention of basic science in medical students. Custers questioned the idea that students forgot most of the class information shortly after the exam (22). After reviewing studies Custers found that basic science knowledge will be retained even after a prolonged period. This is the opposite of the results of our experimental groups' old and new scores, in which we found

a significant score reduction.

Conversely, Bell et al (2008) looked at medical professionals taking an online internet tutorial. The participating doctors took a pre-test and were then randomly post tested at 3, 8, and 55 days post tutorial (23). Bell found that at 3 and 8 days post tutorial the performance decreased by half. The 55 days post tutorial group scores were equal to the pre-test mean. This study correlates with our experimental group results that there is a dramatic loss of knowledge over time.

Calabro et al (2000) also found that knowledge is lost dramatically over time. Calabro et al looked at fourth year medical students enrolled in a infection control training traditional classroom course. By looking at pre and post-tests, the students had a significant increase in knowledge scores after completing the course. The students were tested for knowledge retention two years post course. They found that there was no significant knowledge retention two years after finishing the course (24). These results, although from a traditional course, are very similar to the results of our study. The Science of Energy Balance students had a significant increase in knowledge scores after originally taking the course but two years post course they had a significant decrease in knowledge score.

Of course forgetting is a natural occurrence that our brains experience due to the vast amount of information we are exposed to everyday (23). The best ways to recall knowledge is by actively learning and reviewing information over time (23). Less relevant information tends to be forgotten more frequently due to decreased exposure (23). Therefore, the students who had taken The Science of Energy Balance course may not have found the information relevant to their professional lives and had not reviewed the information since taking the course because it was not one of their university program requirements.

A limitation of this research is the low response rate by the potential experimental group participants. Had there been more experimental participants, the research could have focused on the four time periods as expected. If there were more experimental participants there would have also been a higher statistical power, closer to 80%. Perhaps the most unexpected finding from this study was the results for our control group participants. Our control group was very high scoring, with a mean score of 20.0, when we had predicted the control group to be low scoring. The control group was predicted to be low scoring because they had never formally studied nutrition. The control group mean score for the previous study of Eisenhardt using the same validated knowledge assessment was 14.6 which is 5.4 points lower than our control group mean (21). In fact, studies in the literature would support the unexpectedness of these control group results. In a study by Matvienko et al (2001) as reviewed by Cousineau et al (2006) on the prevention of weight gain in college freshman, the investigators state that, “they [college freshmen] knew virtually nothing about energy metabolism and expenditure”(25,20). Yet in our study, the control group had performed better than students who had taken the online course. The demographic data suggested that the control group was well educated with a scientific background between the ages 20 and 38. The control group participants may have had a prior interest and knowledge of nutrition outside of an educational setting, which reflects in their high scores. Many of the undergraduate majors included biology, neuroscience, and psychology while some of the control group members were graduate students or indicated themselves as University of Vermont staff.

Implications for Research and Practice

In conclusion, students’ knowledge retention from an online nutrition energy balance

course taken one to two years prior was not significantly different from a control group who had never taken a course in nutrition. We were unable to prove our hypothesis that there would be no significant drop in energy balance knowledge over time since there was a significant drop in score between the first and second time that the experimental group took the validated knowledge assessment. Future studies using a larger student sample size and a more carefully selected control group may help explain these unexpected results. There should also be future studies on blended or hybrid nutrition courses, in order to see a greater picture of the benefits or drawbacks of online learning.

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Table 1

| Table 1. Mean Experimental Post Test Scores and Mean Control Group Scores with Standard Deviation | | | | | |
|--|--|--|---|---|---|
| 0 Year Post-Test ^A (Mean ± SD) | 1 Year Post-Test ^B (Mean ± SD) | 2 Year Post-Test ^C (Mean ± SD) | Entire 1-2 Year Post-Test ^D (Mean ± SD) | New Control Score ^E (Mean ± SD) | Old Control Score ^F (Mean ± SD) |
| n ¹ =23 | n=11 | n=12 | n=23 | n=10 | n=26 |
| 22.1 ± 2.50 ^X | 16.7 ± 1.22 | 18.0 ± 1.16 | 17.4 ± 4.37 ^X | 20.0 ± 2.66 | 14.6 ± 4.55 |
| ^A Entire experimental group mean score from the end of the online course. | | | | | |
| ^B Experimental group mean score 1 year from the end of the online course. | | | | | |
| ^C Experimental group mean score 2 years from the end of the online course. | | | | | |
| ^D Entire experimental group, 1 and 2 years post course, mean score. | | | | | |
| ^E Mean of the new control group. | | | | | |
| ^F Mean of a control group from previous research using the same validated knowledge assessment. | | | | | |
| ^X Significantly different from 0 Year Post-Test at P< .001 | | | | | |
| ¹ Number of Participants in group. | | | | | |
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