Implementation of Online Tutoring Program to Increase University Student Information Retention

April Litchford

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IMPLEMENTATION OF ONLINE TUTORING PROGRAM TO INCREASE UNIVERSITY STUDENT INFORMATION RETENTION

by

April Litchford

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

Nutrition and Food Sciences

Approved:

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UTAH STATE UNIVERSITY
Logan, Utah

2015
ABSTRACT

Implementation of Online Tutoring Program to Increase University Student Information Retention

by

April Litchford, Master of Science
Utah State University, 2015

Major Professor Heidi Wengreen
Department: Nutrition, Dietetics, and Food Sciences

Online tutoring program, Mastering Nutrition©, was implemented as a required portion of an entry level collegiate nutrition course. The Mastering Nutrition program incorporates effective teaching pedagogies that initiate information transfer and retention. To test the ability of tutoring program to increase student learning outcomes, a set of questions specific to course learning objectives were asked of students in two consecutive semesters. Questions were administered to students in a pretest, in the final exam, and in a posttest 4-6 months after course completion. Repeated measures analysis of variance reported no significant difference for posttest scores when compared to control scores, p=.595. Pretest data compared to posttest data indicated improvement in student outcomes on the final test for students with the lowest preliminary scores with implementation of Mastery©.
PUBLIC ABSTRACT

Increasing Learning Potential in Entry Level Nutrition Students Through Online Tutorial

April Litchford

This thesis discusses an online tutoring program, MasteringNutrition©, that was implemented as a required portion of an entry level collegiate nutrition course. The tutoring program was introduced to test the ability of the program to improve memory of nutrition information taught during the course. The MasteringNutrition© program combines various teaching techniques that have been successful in increasing student learning. The major techniques discussed include: Socratic questioning, metacognition, and problem based learning. These techniques are incorporated into the MasteringNutrition© program.

To test the effect of the Mastering© tutoring program, ten questions specific to course learning objectives were asked of students in two consecutive semesters. The questions were administered to students in a pretest survey, in the final exam, and in a posttest 4-6 months after course completion. Test scores for both semesters improved, on average, from pretest to final test to posttest. Collected data was analyzed using a statistical program (SPSS). Results of analysis indicated no significant difference in the groups tested over time. Researchers concluded that MasteringNutrition© did not increase student memory of learned concepts. However, further analysis of specific data revealed that students who scored lowest on the pretest reported higher final test and posttest scores when they used the Mastery© program.
ACKNOWLEDGMENTS

The completion of this thesis would not have been possible without the help of Dr. Heidi Wengreen. I would like to thank her for inspiring me to look at the process of education as it applies to nutrition students. I found much value in the knowledge I obtained through conducting my research, writing this thesis, and teaching in the classroom. She gave me a great gift for my future in allowing me a comprehensive experience including research and practice. My future success as an educator will depend largely on what I have learned these past few semesters.

Many thanks must also be extended to my husband and children. Thank you for being so patient with me as I have pursued this degree. Your support and love have been the reason that I have kept moving forward.

April Litchford
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CHAPTER I

ASSESSMENT OF LEARNING RETENTION WHEN ONLINE TUTORIALS ARE COMBINED WITH HYBRID DESIGN CLASS

ABSTRACT

Objectives: Investigate the potential of an online tutoring program to improve learning outcomes of students enrolled in an introductory nutrition course.

Methods: Research was conducted in an attempt to understand which types of teacher pedagogy were most successful in creating efficient information transfer from instructor to student. Research was also conducted to identify several innovative instructional techniques that increase learning retention in students. Research was conducted over the following areas: blended courses, online courses, interactive white boards, computer aided instruction, and online tutorial programs.

Results: Research suggests that incorporating a combination of instructional techniques is most successful. Blended, or hybrid, courses were shown to be the most successful in increasing final exam scores and overall learning retention. An online tutorial program Mastering©, developed by a large publishing company Pearson, was successful in increasing student success in courses of various disciplines.

Conclusions/Implications: Evidence supports the structure of a proposed research project. The use of an online tutorial program in connection with a hybrid design course could prove effective in increasing overall course success and learning retention.
SUMMARY

Opinions vary as to which methods of transferring information from instructor to student are the most effective. The perceived success of one specific teaching method is debatable, but significant evidence has shown that multiple methods of teaching combined together can enhance learning and retention rates in students. This study will explore improvements in education retention that are possible when an online tutoring component is added to a hybrid design class. A hybrid course requires students spend half of their instruction time in a classroom with the instructor, and the other half working through tutorials and assignments online. Students who have completed a beginning hybrid nutrition course will be asked to take a quiz, testing nutrition knowledge based on course objectives, 4-6 months after course completion. We hypothesize that scores from the students that used the online tutorial will be significantly higher than students that did not have access to the tutorial during their course experience.

PROBLEM STATEMENT

College students face enormous pressure to perform in order to meet required grades for various academic programs. Many times the information needed to perform well on assessments is memorized and quickly forgotten. Studies have shown that using various teaching techniques to present course material increases overall assessment scores and retention of learned information.\textsuperscript{1,2} Retention of knowledge gained during a course of study has the ability to impact the lives of students in future endeavors.

This is especially pertinent for students who study nutrition and health behaviors. The majority of students who take introductory nutrition courses at the college level are
incoming freshman, young adults ages 18-21. This population deals with high levels of weight gain, poor dietary habits, and inconsistent physical inactivity. The amount of weight gain seen in young adults 18-29 has increased steadily over the past decade. Increased weight gain during these young adult years may lead students to be overweight or obese later in life, which could have direct impact on overall health.

Several recent studies looked at the effect of online education based interventions designed to improve dietary behaviors. The interventions included education, caloric and physical activity tracking, and discussion groups. Each intervention, while unique in its execution, showed marked improvement in treatment groups. The results of these studies suggest that online nutrition education programs have the ability to motivate behavior change. The idea of interactive, technology based activities has become an innovative way to present information to students in college courses. While the level of learning retention measured in students depends on the technology used, most technology based intervention report at least the same level of learning reported in traditional (lecture based) course structures.

BACKGROUND

Education theories have changed and developed over the past few decades. The traditional method of teaching has been, almost exclusively, presentation of information to students through lecture. Lecture style teaching creates a passive learning environment where students are expected to sit quietly and absorb the information presented by the instructor. In the early 1950’s educators began to challenge the idea that not all students learned best through presentations or lectures. The idea of active
Learning was defined as instructors began to identify that students gained more knowledge when information was presented in ways other than lecture. These unique ways were classified into “learning styles” and educators began to tailor lessons and activities to involve as many styles as possible. Learning styles were defined as the way a student concentrates on, processes, and internalizes the information presented to them. Each individual student was considered unique in how they processed information, but there were some general categories developed that instructors used to increase learning potential in all of their students. Though learning styles were an innovative way to address every student’s unique perspective on learning, they still classified students and forced learning to occur as the teacher dictated.

To address this lack of individuality educators began to compartmentalize teaching into small groups of students in order to promote inquiry based learning. In this instructional method teachers became guides, facilitators, and counselors in order to allow students to dictate their own learning. Academic professionals began to argue for reform in education, they contended that student discovery is a basic and necessary component to education. As student guided learning began to prove effective further research studies concluded that there was a potential link between learning and the physical senses. Teachers were able to increase overall conceptual understanding in students when they included activities that stimulated sight, hearing, and touch. These theories address the fact that students learn in connection with their emotions, that boredom, excitement, apathy, etc. can pave channels in a student’s memory. Teaching methods are still evolving as educators seek ways to improve and enhance the amount of
information that can be disseminated in the most efficient manner. One technique that remained constant through all of the changes in theory is repetition.

Repetition is a vital component in teaching/learning. In order for the human mind to learn and understand a new concept the concept must be shown over and over again. Yet mere repetition does not elicit the greatest amount of learning and understanding, repetition with correction has been shown to strengthen overall understanding. Also, repetition of the same material presented through different methods increases the amount of information a student is able to absorb and understand. Because repetition is necessary for effective learning to take place, teaching methods are constantly changing to include new and innovative ways to present a concept.

One such method is through the use of technology in various forms, i.e. On-line activities, interactive teaching boards (IWB), games, videos, animations, etc. Technology allows for creative and unique ways to introduce information to students and has enhanced learning experiences in many settings. A recent study looked at the use of interactive teaching boards (IWB) as a way to improve student understanding and retention of material. This study concluded that when IWB was used as part of the learning process students scored significantly higher on an assessment given 4-6 months after completion of a language course than did students that were taught with a traditional lecture.

Another study, involving computer aided instruction (CAI), looked at the level of retention gained through use the use of CAI. The study included 136 middle school age students in a traditional, lecture type classroom. The students in the study were divided into two groups, treatment and control. Both groups were taught the same information on
physics through lecture. The treatment group received added instruction in the form of CAI over the course of one academic year.\textsuperscript{11} The control group received added instruction through a supplemental instruction course taught by a teaching assistant. Two assessments were given to the participants, one immediately following the end of the study. The same assessment was administered again five months post study.\textsuperscript{11} The results of the study showed a significant increase in the treatment groups final assessment test scores (p=.00) and post assessment scores (p=.00).\textsuperscript{11}

Technology in its various forms can improve education in some cases, but education completed exclusively using technology does not always transfer information as desired from educator to student.\textsuperscript{1,7} A meta-analysis looked at the effectiveness of exclusively online learning compared to traditional face-to-face learning.\textsuperscript{6} The analysis included 50 independent studies; 27 studies focused on online vs. face-to-face instruction and 23 studies focused on blended instruction (online and lecture) vs. face-to-face instruction.\textsuperscript{6} The study reported no significant improvement in overall assessment scores (p=.46) when using exclusively online technology based education methods. One major concern about online learning is the removal of community during the education process.\textsuperscript{6} Many seasoned educators believe that classroom community, the idea that the students in a specific course help one another grasp complex concepts, is the key to comprehensive learning.\textsuperscript{6} Other traditionalist educators believe that learning has always been effective through lectures; their argument is strengthened by adequate assessment scores in lecture style classes.\textsuperscript{7} Some would argue that adequate is not acceptable. Many institutions of learning encourage the use of teaching methods that will help students excel rather than settle for adequate.
The debate over which form of learning is more effective has led educators to develop and study a new form of instruction. Hybrid or blended learning is a combination of face-face instruction with online technology. The meta-analysis study mentioned earlier in this paper discussed 23 studies that focused on blended (hybrid) courses in comparison to traditional courses. The study reported a significant difference in teaching methods, $p < .001$. Researchers concluded that a combination of lecture and online interaction is most effective for student learning and retention of learning. Hybrid teaching is evolving at a rapid rate and is proving to be an effective method of education.

Due to the success of hybrid education, new ideas on how to make the hybrid experience better and more effective are being tested. One such idea was inspired by the Socratic method of teaching. A Socratic teaching method is based on ideas formed by Socrates many centuries in the past. This teaching method includes trial and error, questioning of absolute thoughts, and progressive suggestions to build lasting ideas. The Socratic design reveals to students what they don’t know through subtle hints or suggestions. This, in theory, inspires the student to develop their own ideas and creates in the student a greater ability to retain what they have learned.

Hybrid courses are proving capable of increasing learning potential and they allow for larger enrollments per course. Demand for the Nutrition 1020 course at Utah State University has grown steadily since 2010. The completion of this course fills a life science graduation requirement for students. It is seen as a desirable option when compared to other course choices. Students also tend to choose this nutrition course because it teaches concepts applicable to their current lifestyle. In order to accommodate the growing demand for this course, instructors and administrators opted to offer the
course as a hybrid. While this course is now capable of enrolling large amounts of students, there is still some dissatisfaction with performance outcomes. Instructors have continued to research other instructional options that could increase satisfaction with course outcomes. One promising area of learning enhancement was found in online tutorial programs.

Recently, a large textbook publisher developed a program for online homework and tutorial helps. One feature of this program is the ability that students have to answer questions multiple times. This type of response pattern was investigated in a recent study. The study used results from assessments given to 142 Newtonian physics students enrolled in an institute of technology. The students were allowed multiple attempts on the assessment, with hints provided for wrong answers. Researchers used a predetermined scale to rank the changes in skill of each individual student from their first attempt to their second attempt. There was a significant improvement in second attempt quiz scores as compared to first attempt, \( p = .02 \). Researchers concluded that the improvement was due to a few factors. Students were offered tutorial hints in both quizzes but were penalized each time they used the optional help tab. Students demonstrated less knowledge associated with concepts during the first attempt and used the help option more. Secondly, there was more tutorial help available to students during the second quiz attempt. Researchers feel that these extended tutorials allowed students to cement a concept due to the expanded information available during their second attempt.

Success of online tutorials has created a market for available programs. Pearson Education released a line of educational, technology based components that are designed
to enhance the learning experience. Pearson is a large publishing company based in the
United States that leads the market in education, business information, and consumer
publishing.\(^{14}\) Pearson’s MyLabs and Mastering\(^{©}\) programs are offered in a wide range of
subjects from English to economics to physical science.\(^{14}\) The cost of the
MasteringNutrition\(^{©}\) program is reasonable and can be assessed to students through
course fees.

A recent study offered insight into one of Pearson’s tutorial programs.\(^{16}\) This
study offered MasteringBiology\(^{©}\) activities as required homework for an introductory
biology class at Monash University.\(^{16}\) The assignments were required as part of the class
grade but they did not have a time limit for completion. Assignments were available for
one week at a time.\(^{16}\) This format helped to even the gap in the level of prior knowledge
that students may have possessed before the class began. Students with a good amount of
prior knowledge coming into the course were able to complete the assignments faster
than those with little or no prior knowledge.\(^{16}\) Also, students who lacked prior
knowledge of the subject were able to learn in a low pressure environment according to
their individual learning needs.

The study also reported that the use of Mastering\(^{©}\) significantly increased
(p=<.001) assessment scores for all concepts taught in this course. Scores on weekly
mini quizzes for each unit given after lectures, reading quizzes, and mastery assignments
were completed rose 7%-15% compared to a previous class that did not include
Mastering\(^{©}\) assignments.\(^{16}\) There was also a significant jump in final assessment scores,
final averages for the Mastering\(^{©}\) group was 61% where the year without Mastering\(^{©}\)
was 59%.\(^{16}\)
Hybrid learning has improved student outcomes, and Pearson’s Mastery activities have been effective in helping students learn and retain more information than through traditional education.\textsuperscript{14,15,16} It seems logical that combining these two methods could enhance the learning experience beyond what has already been seen among student populations. By combining many different types of learning, in many different settings, every student should find one method that will give them the best chance at a productive, thorough education.

**OBJECTIVES**

To assess difference in student’s retention of information taught in NDFS 1020 course that will be taught in a hybrid design before and after introducing online assignments that utilize the Socratic teaching method known as MasteringNutrition.

**RESEARCH QUESTIONS**

1) Will students demonstrate retention of basic nutrition concepts on a post assessment taken 4-6 months after completing a basic nutrition course without Mastering Nutrition component?
2) Will students demonstrate retention of basic nutrition concepts on a post assessment taken 4-6 months after completing a basic nutrition course with Mastering Nutrition component?
3) Do students who participate in MasteringNutrition retain more information 4-6 months after taking the course as compared to students who do not participate in Mastering Nutrition?
4) Does the placement of the MasteringNutrition assignments within the course design influence retention of basic nutrition concepts on a post assessment taken 4-6 months after completing the course.

REFERENCES


CHAPTER II

REVIEW OF INSTRUCTIONAL METHODS USED IN ONLINE TUTORING PROGRAM THAT CREATE EFFICIENT AND EFFECTIVE TRANSFER OF INFORMATION FROM INSTRUCTOR TO STUDENT

ABSTRACT

Objective: Research teaching pedagogy and instructional techniques integrated into online tutoring program that create efficient and effective information transfer from instructor to student.

Methods: Research was conducted to identify several modes of teaching/learning that increase overall student performance and knowledge retention. The studies reported in this paper increase understanding about three defined teaching methods; Socratic learning, metacognition, and problem based learning.

Results: Teacher pedagogy discussed in this paper has been effective in information transfer from instructor to student. Significant improvement in test scores, student learning perceptions, and critical thinking levels are documented in using a variety of different assessments. Conclusions across many different disciplines have been positive and lend credibility to educator efforts to offer innovative course structures and instructional techniques.

Conclusions/Implications: Use of varied and innovative instructional techniques has the potential to increase student understanding of desired material and increase overall learning retention.
INTRODUCTION

The transfer of information from educator to pupil is done in various ways, and through various instructional techniques. Opinions concerning which techniques are most effective vary widely. The perceived success of a single specific teaching pedagogy is debatable, and depends largely on the experiences of the educator/student. While opinions vary, significant evidence continues to be collected emphasizing increased information transfer from teacher to student when multiple methods of teaching are used in conjunction.

The most traditional method of information transfer has long been a lecture based system. Lecture based teaching dates back to early Grecian times, but in the early 1950’s educators began to realize that not all students learn best through presentations or lectures. Teaching systems that use lecture as the primary method of information transfer create a passive learning experience for students. The idea of active learning began to be defined, as instructors began to recognize that all students learn in unique ways. These unique modes of learning were classified into “learning styles” and educators began to tailor lessons and activities to involve as many styles as possible.

Though learning styles were an innovative way to address every student’s unique needs regarding learning, they still classified students and forced learning to occur as the teacher dictated.

To address this lack of individuality educators began to compartmentalize teaching into small groups in order to promote inquiry based learning. Inquiry based learning relies on student generated questions, there is little to no lecturing. In this system teachers became guides, facilitators, and counselors in order to allow students to
Socrates was an early Greek philosopher that lived from 469-499 BC. He was a renowned teacher using teaching methods that were innovative and effective. Socrates used open forum questioning to guide the learning of his students. When the Socratic teaching method is used correctly, it can include experiences that require trial and error, questioning of absolute thoughts, and progressive suggestions that build on each other to form lasting ideas. The Socratic design reveals to students what they do not understand completely through subtle hints or suggestions, requiring students to guide their own learning. Studies have shown that student discovery is a basic and necessary component to education. Discovery allows the student to form ideas in their own way instead of in the way an instructor chooses to explain the idea to them. This gives the student ownership of the idea and increases their ability to store and retrieve the information when necessary.

In the past few decades, active learning has been a common topic of discussion. Universities are looking at ways to change current teaching systems to better serve their students. A few common themes seen throughout current research include; the Socratic learning method, the idea of metacognition, and the use of problem-based learning. These forms of teaching are helping colleges address differences in student learning and meet demand for innovative course designs. This paper will explore these techniques and teacher pedagogy that are intended to allow for active student discovery.

**SOCRATIC LEARNING METHOD**

The Socratic teaching method is based on ideas formed by Socrates many centuries in the past. Socrates was an early Greek philosopher that lived from 469-499 BC. He was a renowned teacher using teaching methods that were innovative and effective. Socrates used open forum questioning to guide the learning of his students. When the Socratic teaching method is used correctly, it can include experiences that require trial and error, questioning of absolute thoughts, and progressive suggestions that build on each other to form lasting ideas. The Socratic design reveals to students what they do not understand completely through subtle hints or suggestions, requiring students
to question the ideas being presented to them.\textsuperscript{4} This inspires the student to develop their own ideas and creates in the student a greater ability to retain what they have learned.\textsuperscript{3}

Often students reject this method of teaching because it requires preparation and forethought. Because a lecture based course is the traditional form of education, students have become accustomed to absorbing information as it is presented by the instructor. Most students will not question information given to them from the instructor, making the teacher the key to changing this habit of learning.\textsuperscript{5} An effective teacher can inspire students to ask questions and think deeply about the concepts being presented. One way to do this is to create a class culture that requires all students to engage in thought provoking questions. This will give the student the ability to challenge assumptions made by the instructor and other class members. It will motivate the student to see inconsistencies in the information presented to them and motivate the student to ask why.\textsuperscript{5} Challenging a student to discover knowledge for themselves allows them to “reinvent knowledge”.\textsuperscript{5} Every individual learns in a unique way, when they gain knowledge for themselves their understanding of the subject is different from their peers. Each student will gain a unique perspective through active questioning that could possibly add innovation to current ideas and concepts.\textsuperscript{5}

The major driving idea behind a Socratic teaching style is thoughtful questioning.\textsuperscript{6} Thoughtful questioning has been shown to enhance critical thinking abilities in students. The active interaction of asking questions and forming new questions allows the student to explore every nuance of a subject. Students learn as they develop questions and receive answers to their questions. This circular thinking exercise has been shown to improve student ability in critical thinking; advancing student ability to face real-life
situations with ease and innovation.\textsuperscript{6} Many educators believe that Socratic teaching has the ability to develop critical thinking among their students.\textsuperscript{6}

This technique has been successful across many disciplines, but care must be taken as instructors begin questioning exercises. Two recent studies looked at the types of questioning occurring in a clinical teaching setting.\textsuperscript{7} The majority of the questions asked by faculty members, as high as 91\% of questions posed in the classroom, were determined to be lower-order questions. Lower-order questions fail to produce deep thinking that leads to cognitive improvement, and are often spontaneous.\textsuperscript{7} Correct Socratic questioning includes stratification of inquiries. This requires advanced planning of questions that will be asked and when they will be asked. The questions must build on each other to emphasize basic concepts, while guiding students to expand their knowledge towards more complex ideas.\textsuperscript{7}

Student led questions have also shown to be an effective exercise in deepening student understanding.\textsuperscript{7} The same studies mentioned above also explored the effectiveness of student generated questioning. The instructors in these studies were able to generate conceptual understanding by making declarative statements that would encourage students to ask questions.\textsuperscript{7} This exercise in forced questioning was especially effective when there seemed to be no easy answer to the question. This required student and teacher to work together to discover the solution.\textsuperscript{7} The researchers concluded that students exhibit greater complex thinking and engagement in various subjects when student questioning is part of the learning experience.\textsuperscript{7}

Another study looked at the type of questioning that occurred among elementary students in Ontario, Canada. Four different elementary classrooms of second and third
graders were studied. The purpose of the study was to assess the effectiveness of different types and levels of questioning. The students were asked to sort questions into two categories: surface and deeper. A surface question was defined as one that would prompt students to imitate, recall, or apply knowledge as taught by a teacher. Deeper questions were defined as questions that cause students to create, analyze, or evaluate. These questions tend to be open ended and divergent in nature. The activity of sorting was an attempt to teach students how to generate deep, or productive, questions that would help them gain the knowledge they were seeking. One of the major criteria required for this questioning included open ended questions. An open-ended question requires the respondents to give details, and/or provide an explanation.

After students had a basic understanding of the type of questions needed for deeper understanding, each classroom was given the same problem to solve as a collective group. The teachers initiated discussions with a few questions and then, with the help of research assistants, recorded the questions that students asked to the teacher and their peers. After the activity had concluded the researchers separated the questions recorded into three categories; surface, deeper, or unclear. The students were retaught the idea of deep questioning and the groups were again given a common problem to solve. The researchers continued to record questions and sort them into the designated categories.

This method of deep questioning and free discussion was then implemented in the targeted classrooms for a few more weeks. At the end of the time allotted for the study, students were given a common problem to solve and the type of questioning used by students was recorded. When data was compiled and analyzed the percent of deep
questions asked by students had increased by 40%. It was also noticed that the amount of
questions asked by students increased dramatically during the post test. Researchers
concluded that as the student’s ability to form clear questions and answers increased
through this exercise. Researchers also noticed that the writing ability of students
became more clear and concise. This strengthened the theory that student understanding
of key topics increased as the quality of individual inquisition increased. Although the
use of questioning may have shown a positive increase in student understanding, the
question still remains whether students perceive this method as effective to their overall
learning.

One study explored the difference between lecture based learning and Socratic
based learning. Subjects were undergraduate students (n= 227) enrolled in an
introductory public relations course at a southern American university. Students were
assigned to either the traditional lecture style course or a course using a modified Socratic
method. Students self-selected into the courses without prior knowledge of the course
structure. Pre and post questionnaires were used to assess any difference in the groups.
Focus groups of randomly chosen students (n=50) were also held to assess effectiveness
of the courses. The Socratic based course required students to complete assigned
readings before class. The instructor then used well placed questions to conduct a
discussion of the problem the student’s needed to solve.

Assessments for the courses included essays and multiple choice questions based
around the principles discussed in the readings and discussions/lectures during class.
Significant increase was seen in the critical thinking and problem solving skills of the
Socratic students (p= <.01). Many of the students in the Socratic section reported that
more opportunities to think critically helped them develop skills that allowed them to be successful in this type of learning (<.05). The factual knowledge gained by both groups did not vary significantly; the only major significance seen seemed to be in the ability of the Socratic learners to solve problems better than the lecture based students (p=.05).

Problem solving through critical thinking is the goal of most technical courses. How this can be achieved was studied in a quasi-experimental study that compared Socratic inquiry based method with traditional lecture method. Two different sections of the same course were taught; each course was taught by the same instructor and used the same textbook. Identical topics were covered by each section. One section of the course was presented as a didactic lecture; the other was presented in a case-study format. The case-study format included three elements; clinical case studies, group work, and lecture/content discussions. In the lecture format the students were instructed through conventional lecture practice which elicited very little student interaction. The study was conducted over two consecutive years, covering three different sections. Students were evaluated for increase of critical thinking skills through pre and post-tests; students were also analyzed for exam and course grade performance.

The results of this study reported marked increases in favor of the Socratic teaching method. Final exam scores were significantly higher than the didactic students (p=.001). Overall, when using Socratic questioning students had 12% higher final exam scores and 11% higher final grade scores than the didactic students. The study used a renowned critical thinking test called, California Critical Thinking Skills Test. This test has been used in several other studies and has been deemed effective by experts in the field of psychology. The didactic students that took this test only gained three national
percentile ranks where the Socratic students gained 7.5 percentile ranks (p=.001).\textsuperscript{10} The marked improvement in critical thinking scores and overall final grades lends credibility to Socratic pedagogy.

While Socratic pedagogy has shown to be an effective way to disseminate information, student preference of teaching methods is also a concern for many educators. A cross-sectional study was conducted to determine class structure preference in a medical school in India. Due to high enrollment in this area, administrators needed a teaching method that would be effective despite large class sizes.\textsuperscript{11} Second and third year medical students were asked to rank the types of teaching methods they were subjected to in the classroom on a Likert scale. The sample included 286 students, with 56\% of the students being female.\textsuperscript{11} The lectures that were given to these students followed the Socratic pattern and were preferred over didactic lectures. Further comments revealed that students felt the didactic lectures to be boring and monotonous.\textsuperscript{11} Students in the study felt that the Socratic questioning improved their thinking and gave them the ability to voice their opinion.\textsuperscript{11}

A few other studies reported similar results as the study above. All tested preference among students and all of the studies found that Socratic pedagogy was preferred by students.\textsuperscript{10,12,13} Socratic questioning was also more effective than the lecture based didactic method of teaching.\textsuperscript{10,12,13} Comments from the respective studies gave explanation for student preference. Students felt that Socratic structure forced them to be active and alert through the whole lecture. It was also noted that the active participation helped the students to feel that they knew the subject matter better than if information was delivered to them through didactic lectures.\textsuperscript{13} The active participation encouraged by
the Socratic pedagogy also created a more enjoyable and engaging learning environment. Not only did preference increase with Socratic teaching, but scores on tests and assignments were higher than those in a traditional lecture course. In both studies, the overall test and assignment scores were used as a comparison between the students taught with Socratic questioning and the students taught with the lecture method. Both studies reported a significant p-value, <.05.

By encouraging students to think independently instructors give them the ability to discover their own knowledge. Socratic questioning also allows students the ability to form innovative ideas because they are not dependent on a teacher telling them what they should know. They gain an understanding of a topic on a deeper level because they are forming the knowledge for themselves. Questioning can begin to help students form knowledge, but they must also be taught how to evaluate the level at which they understand.

META-COGNITION (SELF-DIRECTED LEARNING)

The concept of metacognition embraces the ability of students to measure what they learn and how they learn it. Metacognition is the idea that students gain more understanding of concepts when they spend time reflecting on what they have been taught. Experts contend that there is more value in the student’s evaluation of what they have learned than in the teaching of the information. John Flavell was a developmental psychologist that defined this learning process and introduced it into the field of education in the 1970’s. He defines metacognition as follows:

Metacognition refers to one's knowledge concerning one's own cognitive processes or anything related to them, e.g., the learning-relevant properties of
information or data. For example, I am engaging in metacognition if I notice that I am having more trouble learning A than B; if it strikes me that I should double check C before accepting it as fact.\textsuperscript{14}

Additional perspectives have expanded Flavell’s theory to create the idea of metacognition as it is now defined. This method emphasizes self-regulated learning that is structured into three distinct steps: planning, monitoring, and evaluating.\textsuperscript{14} This method has been effective in helping students create concrete knowledge. The problem lies in how to teach students to monitor their own learning.\textsuperscript{14} Educators struggle with how to present this idea to students and how to assess the effectiveness of their teaching. They must teach students to understand how they are thinking and introduce effective study tools that are flexible allowing students to tailor and change the tools to meet their individual needs. Metacognition is essentially an internal process that is uniquely individual to every student. This requires a broad teaching style that is inherently flexible.\textsuperscript{14}

One recent study looked at the effectiveness of electronic response systems for in-class quizzes. The study included 198 students from a large Southwestern university in the United States. Three sections of the same undergraduate psychology course were studied over the course of a semester. The aim of the study was to measure whether use of Iclickers, as part of a college course, would help students gain higher metacognitive ability.\textsuperscript{15} The students were assigned either to Iclickers or paddles, which are a low technology flashcard system that showed student answers to the instructor. Students were given the same lecture format by the same lecturer in all sections.\textsuperscript{15} Students were asked to answer the same set of questions. If enough students missed the question, the instructor asked them to collaborate among themselves to determine the correct answer.\textsuperscript{15}
In order to measure metacognition, each student was given three surveys; pre, mid-study, and post. The survey that was used is called MSLQ, it is a survey that has been effective at measuring metacognition. The MSLQ survey used a metacognitive attribution to feedback device scale in order to measure changes in metacognition.\textsuperscript{15}

The study reported that mean quiz scores improved steadily during the semester for both the Iclicker and paddle groups. This suggests that both methods tend to increase metacognition in students. However, overall performance on quizzes was more significantly improved with the use of Iclickers.\textsuperscript{15} Researchers believe that the increase seen is due, in part, to an increased engagement in the lecture. Iclickers and paddles required students to be more prepared for the lecture and to stay engaged for the entire duration of the lecture.\textsuperscript{15} Researchers also believe that using Iclickers during the lecture allowed students to be more aware of their metacognition because they provided immediate feedback on what the student did or did not understand. The MSLQ survey also showed significant improvement in the Iclicker group (\(p=.005\)) and the paddles group (\(p=.001\)), when compared to a control group. The results of the survey suggest that metacognition can be improved through use of consistent feedback during teaching.\textsuperscript{15}

Another study looked at the effect of using assessments as a way to teach metacognition.\textsuperscript{16} This study was based on two examples of a collaborative dialogue process between students and teachers concerning assessment results. The data used in this paper was taken from a larger cross-sectional study of K-12 classrooms that studied 5\textsuperscript{th} grade students from a low-income, racially diverse school.\textsuperscript{16} This type of metacognitive activity helps students to measure their own performance on an assessment,
which in turn helps them to look internally to discover what they still do not understand. This type of questioning is sometimes referred to as data driven dialogue.\textsuperscript{16}

Data driven dialogue (DDD) consists of four parts; predict, explore, explain, and take action. Students are expected to first, predict the score they think they received on the assessment before they see their test score. Then students are asked to identify which items on the assessment fit directly with their individual learning goals and asked how they felt they did in achieving those goals.\textsuperscript{16} Students then explain what they did well on the test and why they received the scores they received. Last, students make goals that will help them to improve their performance of future assessments.\textsuperscript{16} This occurred in a discussion type setting with the class as a whole discussing the learning objectives and assessing what level of individual understanding they achieved.

In order to measure teaching techniques and student responses, researchers set up a system of video and audio tapes within the classroom to capture response data. They also used teacher and student interviews to gather data.\textsuperscript{16} These recordings were taken consistently over the two year course of the study. The teacher remained constant during the study, but there were different students studied. The teacher was required to train for a year with other experienced (DDD) teachers before beginning the study.\textsuperscript{16}

The tapes from the study were viewed by all of the authors of this paper and were judged using pre-determined categories to assess changes in student meta-cognition. Researchers found sufficient evidence to suggest that meta-cognition did improve when students spent time analyzing their performance on assessments.\textsuperscript{16} Students were better able to understand what they had done wrong, and make necessary adjustments to their learning that would help them perform better on subsequent exams.\textsuperscript{16} Researchers also
found that the dialogue constructed by the class as a whole changed the nature of learning for the class as a whole. As the students discussed their results as a class they began to understand that they were responsible for their own learning. The students also began to understand that they had various resources that they could employ to enhance their learning, i.e. themselves, the teacher, and their peers. While this data is not quantitative in nature, it does lend valuable insight into possible techniques to improve metacognition. Due to the internal nature of metacognition, quantitative assessment is difficult as every individual thinks and learns in a unique way.

Other studies have looked at the effect of self-reflection as a means to measuring metacognition. Two recent studies used a system of self-reflection and pre-assessment to increase collegiate level student ability to recognize their individual level of understanding. Formatted reflection sheets were used to keep students moving in the right frame and avoid deviations from personal performance evaluations. The goal of the reflection activity was to help students understand their current level of learning as they were actively learning a new concept.

The first study was conducted on a small scale and tracked entry level college students (freshman) over the course of six weeks. A standardized survey was given to participants before and after the study was conducted. A significant increase (p=.001) was seen in self-reported metacognition over the course of the study. Scores used for comparison were taken from the results of a common metacognitive assessment tool called, Metacognitive Awareness Inventory.

Students also engaged in personal reflection exercises throughout the study. As part of this self-reflection students were asked to predict their grades on certain
assignments and tests. This is also a common measure of metacognition. Student predicted grades were compared to their actual grades to assess improvement in metacognition. A positive correlation of $p=.016$ was seen in students when compared to each student’s baseline results. Researchers concluded that by the end of the study, students were more aware of their own individual learning process. The self-reflection exercise seemed to positively impact student metacognition.

The second study was conducted over the course of a semester and included nine beginning Spanish classes and three beginning French classes at a mid-western university in the United States. This study comprised of 168 freshman level students, with the French students ($n=47$) acting as control. The class structure for all of the courses was divided into sections, or units. Each unit began with a series of questions that required students to rate their confidence with the upcoming subject matter. Once the unit was completed, they were again asked to complete the same survey and a short section on goal setting. The goal setting section asked students to specifically evaluate their performance in the past unit and look forward to how they would perform on the next unit.

The results for the actual metacognition were not as concrete as researchers would have liked. There were some problems with the survey used due to varying levels of student comprehension. However, there was some success seen in the student/teacher perceived effectiveness of the course. Students and teachers both felt that the reflection exercises were helpful and productive to the learning process. Also, when student scores were compared to the control group a significant increase was observed. Overall, researchers felt that the action of monitoring learning through self-reflection enhanced
the learning experience for the students in the treatment group of the study.\textsuperscript{18} Another study incorporated this idea of self-reflection into an entry level university chemistry course.\textsuperscript{19} This study sought to create a more concrete way to quantify increases in metacognition. Historically studies conducted to measure metacognition have used self-reported measures to make claims. This study employed a multi-assessment method in order to produce quantitative data that would produce strong conclusions.\textsuperscript{19} Participants were asked to generate self-reports on the progress of their learning. They were also asked to use two automated instruments to generate data. The first is called Metacognitive Activities Inventory (MACI) and is based on a 5-point Likert scale, the second is an online tracking tool called Interactive Multimedia Exercises software (IMMEX).\textsuperscript{19} IMMEX uses an HTML platform that tracks participant’s actions while problem solving. This program has built-in neural networks that provide characterization of the problem solving abilities of students.\textsuperscript{19} Both of these surveys have proven to be robust and reliable measures of metacognition. Each survey was administered to students as pre and posttests.

The data was collected in three separate phases. In phase one each student was given a non-chemistry problem to solve with an assigned group. The students were directed in their problem solving through prompts and collaboration. This phase was measured with collective reflection on the problem solving experience.\textsuperscript{19} In the second phase students were given a choice between two non-chemistry problems. They were then given fewer prompts from the instructor and asked to solve the problem as homework. This phase was measured through individual reflection on the process.\textsuperscript{19} The last phase asked for general feedback and comments in a common meeting.
Little difference was seen in the various tests when participants were compared to the control group, (p=.07). However, significant changes were seen in the participant’s pre and post test scores of the MACI and IMMEX surveys (p=<.001). It was also observed that students were more capable of solving the problems posed to them at the end of the study. This suggests that through the intervention employed by this study, metacognitive ability increased. Researchers concluded that the methods used in this study were effective in increasing metacognition among college students.

Increasing metacognition is desirable, but does increased metacognition increase a student’s ability to gain conceptual understanding? One study looked at the relationship between metacognition and the ability to understand scientific concepts. The intent of the researchers was to build a training program for secondary science teachers that would help them incorporate metacognition as a skill into their science curriculum. The study included 28 secondary science teachers and 648 secondary students. The study was conducted in two sections beginning with a professional development course designed to include discussion about metacognition woven into discussions on scientific concepts. In the first phase of training, instructors were led through a discussion on a scientific concept. After the discussion concluded the instructors then visited several inquiry stations where they could explore the subject further while learning how to increase metacognition. Each station challenged the learner to assess their experience and what knowledge they had gained. In order to measure increases in metacognition of participants researchers developed a chart that defined various levels of conceptual understanding. The teachers were asked to assess where they felt they were in their understanding after every inquiry station.
After completing several training sessions the next step of the study was implemented. This step required each teacher to use a specific lesson plan template to build a lesson following the guidelines they had been taught during the professional development training. The teachers created lessons similar to those they had experienced in the training which they then presented to their students. Each instructor tracked student progress using the same chart for measuring metacognitive increase used during the training sessions. The teachers were then asked to write a reflection paper and take a post pedagogy of science teaching assessment (a similar pre-test had been administer before the professional training). The teachers were also required to participate in a final interview.

The results of the study showed a positive increase in understanding during the course of the classes. Initially teachers found it difficult to encourage their students to think on a different level, students did not understand how to think about their thinking. But as time when on teachers felt that their students, overall, had gained a greater ability to measure what they knew and what they needed more time on. Teachers reported that as the students became more comfortable with the inquiry activities, the quality of discussions improved.

The results of the teacher pre and post surveys proved to be inconclusive due to poor post survey completion. The students in these classes were also administered pre and post surveys which were designed to test how student understanding of the nature of science had changed. A significant change was observed during the course of the experiment (p=<.001). This study showed that teaching students how to improve their
metacognition, in connection with subject learning can be an effective way to increase understanding.\textsuperscript{20}

Another aspect that is critical to the process of increased metacognition is repetition. Metacognition relies on the idea that repetition is necessary to fully learn a concept.\textsuperscript{21} A recent meta-analysis study explored the growing amount of literature on this subject.\textsuperscript{21} According to research, students need to be taught a concept several times in order to gain understanding. Research also suggests that concepts are better received when there is space between each teaching occurrence.\textsuperscript{21} This was due to a fatigue seen in brain processes, when there is space added between learning occurrences the brain shows less fatigue.

An interesting fact was discovered through a handful of applicable studies. Adult students tend to prefer massed learning instead of spaced learning.\textsuperscript{21} Massed learning occurs when a student spends several hours in the same day working on or studying for one particular class or subject. Spaced learning occurs when a student studies small parts of a subject over many days or study sessions. The recall of the learning, however, tends to be less than desirable as the student gets further away from the massed learning session.\textsuperscript{21} This meta-analysis cited looked at >17 studies that attempted to show change in final exam scores by varying study techniques.\textsuperscript{21} Exam scores for the spaced learners in nearly every study exceeded those of the massed learners. The overall conclusions of this meta-analysis encouraged spaced study as the optimal way to excellent learning retention.

It is challenging to measure and study metacognition, as metacognitive processes are inherently personal and individual. Creating assessments that will effectively measure
metacognitive increases are difficult at best. Several metacognitive surveys have been created in hopes of gathering higher quality data. These surveys, as mentioned above, have been validated for precision, and work is ongoing to improve and create better assessments. The review of literature seen in this paper does emphasize the need to improve and enhance metacognition in students. Instructors need to be trained in pedagogy that will encourage students to look internally in order to foster greater understanding and subject mastery.

**PROBLEM BASED LEARNING**

Another emerging pedagogy that is producing strong, independent thinkers is problem based learning (PBL). The focus of PBL is to allow problem solving to guide the learners. By thinking critically about the problem, students will begin to grasp the concepts outlined by the instructor in their own way and time. The process is developmental and requires the student to think at different levels in order to gain complete understanding. Concept is built on concept as the nature of the problem becomes more complex. This method has been suggested by experts to help students develop better interpersonal skills and greater ability to understand complex concepts.

An innovative educator, Howard Barrows, began using PBL in a medical school setting. He was convinced that students should be able to do more than pass multiple choice tests. Barrows created a structure of learning that required students to interact, research, and think. This innovative style of teaching has spread through many other disciplines and is now considered a staple of education. Howard describes four keys to the PBL teaching method. First, problems must be presented to the learner as they
would be experienced in real life. In order to create an authentic learning experience, the
teacher must give students unstructured. This allows for many different hypothesis for
solutions and treatments. Second, the students must take responsibility for their own
learning. The student is responsible for choosing appropriate resources and monitoring
and assessing their own performance and that of their peers. Third, the teacher becomes
more of a coach, or guide. They are not the central figure in the learning process, the
student is. The relationship between students and teacher is more of an adult-adult
distinction rather than a parent-child relationship. The last criteria for this method is
relevant problem material. The problems must have specific application to the student’s
future career. Barrow’s idea was to give students valuable experiences during their
schooling that would allow them to be competent professionals.

The work of Barrow has inspired many other educators to pursue this course of
instruction, the literature is constantly growing in support of this type course structure.
Hmelo-Silver is one such educator that supports PBL learning as a means to encouraging
students to take responsibility for their own education. She contends that this allows
students to construct knowledge in their own unique way, enhancing the learning process.
Another key element of PBL that improves the learning process is the team collaboration
at the heart of PBL. Students learn to listen to new ideas from a wide variety of people
of different backgrounds, this diversity adds depth to learning as idea is built on idea.
The success of courses centered on PBL has increased the credibility of this method to
successfully transfer information to students.

A course based on PBL principles was presented to students enrolled in two
completely different university courses, Forestry and Math/economics. The courses
were evaluated using outcome based assessments; the expected outcomes were set for each course before instruction began. Each course presented students with a problem that they had the knowledge to solve. Each subsequent problem built on the knowledge they gained in the previous problem set, requiring increasing critical thinking as the course progressed. Student reports were examined for understanding based on the outcome criteria established at the beginning of the course. Students were provided feedback on which criteria they had met and which criteria needed more thought, grades were given based on this feedback. Researchers used a weighted grading system to classify students in order to draw conclusions about educational improvements.

The results of this study showed a positive increase in the first two attempts students made at problem solving. After the first two attempts, improvement in problem solving began to level off. Researchers believed this occurred because students became more practiced in problem solving and gained a deeper understanding of learning requirements. The students in the math course showed a higher learning curve in performance and rate of grasping outcomes than students in the forestry course. This could have been due to more complex problems being presented to the math students versus the forestry students. Care must be taken, however, to increase complexity of problems slowly. This study found that when the complexity of the problems increased too quickly, students demonstrated difficulty in mastering the learning criterion. When students were presented with problems that slowly increased in difficulty, they were able to master the concept more quickly.

Another major component of PBL is the need to allow students to work together towards a common goal. This type of learning allows students to feel the satisfaction of
excelling in areas where they are competent, while learning from others in areas where they need improvement.\textsuperscript{26} This promotes a higher level of thinking in students that can increase student competence and confidence in the subject as a whole.\textsuperscript{26} Student interaction paced through the duration of a problem allows students to begin to construct their own meaning of the information presented to them. This creates an ability to remember and retrieve information when needed.\textsuperscript{26} Through PBL, instructors seek to impress knowledge upon student minds that will become deeply ingrained in their psyche.

One way that educators can increase learning retention in students, is to create an environment where students gain a desire to learn. PBL has been shown to increase desire in students to learn subject matter that they had not enjoyed in previous classes. A recent study looked at the effect of PBL on students in a high school Algebra II course.\textsuperscript{27} The goal of the study was to address the attitude of students towards learning mathematics.

The study involved 40 students; the students were to be taught using PBL instead of the traditional lecture/homework class structure previously used.\textsuperscript{27} Students were separated into groups and were given problems sets to solve. The teacher did not provide basic instruction, he/she offered feedback and guidance as students worked together to figure out solutions.\textsuperscript{27} Students were surveyed at the end of the study to ascertain satisfaction with the course structure. When asked how well they liked the PBL structure, students scored it 6.667 out of 10. While this number may not be as high as expected, comments from students expressed an improvement in their overall satisfaction with the subject. Of the 40 students polled, 23 reported that experiencing math through
PBL helped them to enjoy math more than in past classes.\(^{27}\) The connections to real-life problems allowed students to relate to the material, which in turn created more interest in the subject.\(^{27}\)

Some concerns surround the concept of PBL. Many educators recognize that PBL can enhance critical thinking and other relevant professional skills, but may lack the ability to help students acquire adequate factual knowledge.\(^{28}\) A recent study sought to address this concern by testing university level biology students. The study was composed of two groups, 60 students in each group. The students were exposed to two different teaching methods based on their assigned group. Both groups were taught the same information about biology, but each group was taught using a different teaching method.\(^{28}\) The first group learned the material in a lecture based (traditional) format over a 9 month period. The second group was divided into groups of 8-10 students and given nine problems to solve over the course of nine months.\(^{28}\) The students were given 3 weeks to study each problem; each problem was designed to cover specific learning objectives. The students were given two “working sessions” per week, one with a tutor and the other as an independent group.\(^{28}\) The main role of the tutor was to argue agreed upon points in order to stimulate new ideas and discussion.

The cohorts were evaluated using a specific test that was designed to test the amount of factual knowledge students had gained during the study year.\(^{28}\) T-tests were used to compare scores between cohorts. Also, a chi-square analysis was conducted to assess which kind of knowledge was acquired better by each cohort. All statistical tests run were significant, \(<.05\). Students were also asked to fill out a questionnaire at the end of the study in order to assess individual competencies.\(^{28}\)
This study intended to conclude that there was no significant difference in factual knowledge acquisition between traditional courses and PBL based courses. The outcome data agreed with the hypothesis. Both methods of teaching helped students gain a similar amount of factual knowledge.\textsuperscript{28} Difference in the satisfaction of students between the two methods was documented. Students preferred the PBL method over the lecture based method, as stated in a post study questionnaire. A few reasons they cited are as follows: better critical thinking development, ability to participate in cooperative work, and enhanced communication skills.\textsuperscript{28} This study was unable to conclude that PBL was better than lecture methods, but it did provide strength to the argument that PBL will not hinder factual knowledge gain.

Other studies have shown an increase in critical thinking and content knowledge through the use of PBL. These studies all approached measuring increase in critical thinking and content knowledge in a similar way.\textsuperscript{29,30,31} Each study employed pre and post-tests that focused on confidence in critical thinking skills. All of the studies also asked students to rank their abilities in critical thinking throughout the course either by journal type reflections or Likert scale responses.\textsuperscript{29,30,31} Participants of these studies ranged from secondary students to second year university students. Each study reported significant increases in gained critical thinking skills through PBL. Students consistently reported better experiences with course structure when PBL was employed as the teaching method. These studies also reported higher exam score and overall class scores for the students in the PBL (treatment) groups as compared to control groups.\textsuperscript{29,30,31} Researchers in all of these studies found that PBL was an effective way to transfer information from instructor to student.
PBL has been shown to increase the amount of knowledge gained by students in various subjects and levels of learning. But caution should be used when instructors are deciding how much PBL should occur in their respective fields. PBL fatigue has been noticed among some instructors and tutors involved in this type of pedagogy. Tutors/instructors have a tendency to begin lecturing during discussion time instead of allowing the students to direct the discussion. This can lead to an erosion of the benefits of PBL, requiring steps to be taken to change the format of PBL courses. Fatigue among students has also been reported. Students become tired of the same structure and procedure when discussions are conducted among a group. They begin to develop a “free-rider” attitude that causes them to limit their contribution to group work. Observation of such trends has prompted curriculum developers to discover ways to prevent this fatigue from occurring.

Cxabanowska, Moust, Mier, et al, the authors of this paper, created a more structured method of presenting PBL that should reduce fatigue among students and faculty. They created a PBL model that consists of four phases; sensitization, exploration, integration, and application. The writers believe that because learning is an incremental process, each step must be addressed to gain the best learning outcome. Staff training is a major proponent of this system of PBL. The staff was subjected to multiple training sessions to teach them how to create a group community where everyone participated. They were also given tools to help them encourage students to direct their own learning. Staff was encouraged to expand the resources they drew from during discussion to keep them fresh and up to date.
PBL has been shown to be an effective instructional technique in multiple studies. The evidence supports careful discussion about possible changes to current instructional programs. Using PBL could enhance student experience in the classroom creating desirable programs that would keep students interested and engaged.

**CONCLUSION**

The three learning methods mentioned in this paper have demonstrated desirable effects in teacher/student discourses. The research discussed suggests that inclusion of each of these methods could improve the transfer of information from the instructor to the student. The question still to be answered is whether inclusion of several of these techniques into an entry level nutrition course could enhance the education experience even more. Each method discussed could be used in connection with the others in an attempt to expand student thinking, and hopefully student knowledge. It is possible that designing a course using all three methods could produce a learning experience that would prove to be innovative and comprehensive.

**REFERENCES**


CHAPTER III

INCREASING LEARNING POTENTIAL IN ENTRY LEVEL NUTRITION STUDENTS THROUGH ONLINE TUTORIAL

ABSTRACT

Objective: To examine increases in overall knowledge gained and retention of knowledge gained through implementation of an online tutoring program, MasteringNutrition©, into an introductory collegiate nutrition course.

MasteringNutrition© was developed by Pearson, a large book publishing company, and is a companion to the textbook Nutrition From Science to You.

Methods: Students enrolled in two consecutive semesters (fall 2013 n=86, spring 2014 n=410) were asked to complete a 10-question assessment testing basic nutrition knowledge in either content memory or understanding of concept application. Assessments were completed the first week of class, as part of the final exam, and 4-6 months after class ended. The questions were designed to test student knowledge of course learning objectives. Students enrolled in the course the semester prior to the implementation of the MasteringNutrition© platform (spring 2013 n=182) answered similar questions on a final exam, and the same ten questions 4-6 months after they completed the course.

Results: Paired sample t-tests were used to examine differences in mean scores over time by group (Mastering© fall 2013, Mastering© spring 2014, Control spring 2013). Test scores for each Mastering© group improved from pretest to final test(p=<.001), test scores decreased from the final test to posttest (p=<.001) regardless of group. Analysis
of variance was used to examine differences in the mean scores between groups. There were no differences in mean scores at pre, final, or posttests between groups (p=.592, p=.518, p=.518, respectively). Another analysis was conducted using a split variable for assessment scores, above the mean and below the mean. This analysis revealed significant differences between groups over time. The students that were in the below mean group had larger improvements on test scores from the pretest to final test than those in the above mean group (p=<.001). Test scores for the posttest for both groups were similar across time.

Discussion and Implications: Research concerning Pearson’s Mastering© programs have reported positive increases in student scores in various collegiate courses. However, implementation of online tutoring program, MasteringNutrition©, did not significantly improve overall student outcomes in an introductory nutrition course. Implementation of MasteringNutrition© improved basic knowledge of students that entered the course with background knowledge in nutrition below the mean.

INTRODUCTION

Various instructional methods have the ability to change the amount of knowledge acquired by students in collegiate/university courses. The history of education is riddled with large amounts of research concerning the effectiveness of various instructional techniques.\textsuperscript{1,2} Traditionally, instructional methods employed at a collegiate level consisted largely of lectures. Students would attend class to be “spoon-fed” information that they would then memorize and regurgitate during assessments.\textsuperscript{1} This type of instruction has proven to be effective in accomplishing some objectives in
education. One major advantage noted is the ability to present a large amount of
information quickly, to a large audience.\textsuperscript{1} While lecture based teaching does have its
advantages, many seasoned educators/education researchers would argue that the benefits
are severely outweighed by the disadvantages.\textsuperscript{1, 2}

One of the largest disadvantages of lecture based teaching lies in the passive
nature of information transfer.\textsuperscript{1, 3} Studies have concluded that active participation in the
classroom enhances student comprehension and subsequent retention of subject matter.\textsuperscript{3}
This idea of active learning has sparked a revolution of traditional teaching methods.
Various innovative educational theories and instructional methods have been developed
in an attempt to increase the effectiveness of information transfer from instructor to
student.\textsuperscript{1} Scientific evidence supports the use of several teaching methods, and the use of
these methods has become common in collegiate classrooms worldwide.\textsuperscript{4, 5, 6}

Various forms of teacher pedagogy have significantly increased learning success
when they are employed as part of a course structure. These include the Socratic method,
metacognition or self-directed learning, and problem based learning.\textsuperscript{4, 5, 6} These
techniques encourage students to be actively involved in learning and have contributed to
increased learning retention of subject matter.\textsuperscript{4, 5, 6} A combination of these techniques
could potentially create a comprehensive learning program that may significantly
enhance student performance and learning retention in a course of study.

The course discussed in this study is designed around the instructional techniques
mentioned above. The course is taught in a blended format, students attend one lecture
weekly and then complete assignments online at their own pace. The course includes an
online tutoring program called MasteringNutrition© (Mastering©). MasteringNutrition©
was developed by Pearson, a large publishing company. Pearson claims that Mastering© platforms have the ability to increase student performance in courses of various disciplines.\textsuperscript{7, 8} The nature of the blended course format and the Mastering© program combines different teaching pedagogy into one course design. One pedagogy that is incorporated into Mastery© is Socratic questioning. Socratic questioning uses progressive questioning to build student understanding of concepts.\textsuperscript{9} Many proponents of Socratic course structures believe that students are actively engaged through direct questioning.\textsuperscript{9} Progressive questioning is thought to create active brain patterns that help students store and retrieve information more efficiently.\textsuperscript{9}

The use of questioning in Socratic patterns can create differences in the level of active learning, sometimes termed critical thinking, experienced by students.\textsuperscript{10} A study investigated the ability of questioning to increase critical thinking in students. The implementation of Socratic pattern questions into an online veterinary science course resulted in significant improvement of critical thinking (p=<.001).\textsuperscript{10} While questioning may improve student critical thinking ability, care must be taken when determining what type of questions will be used.

The types of questions used in Socratic pedagogy vary widely in depth and scope.\textsuperscript{11} A review was conducted using empirical data to analyze the types of questions used in Socratic instruction. Questions were categorized using cognitive levels in several domains.\textsuperscript{11} The reviewers concluded that carefully thought out questions that promote new insights and comprehensive exploration of subject matter improve knowledge gained in students.\textsuperscript{11} They also found the reverse to be true. When poorly
crafted questions were given to students, learning was hindered. Poor questions included those that intimidated students, were confusing, and limited creative thinking.\textsuperscript{11}

Pearson has included several different forms of questions in the Mastering© program. The hope is that the types of questioning used by the Mastering© program increases active participation in students. Students are given a problem/question to solve, if the student marks an incorrect answer they will be given a prompt to where the information can be found in a text or other source. The student is given three attempts to answer the question, with two different sets of prompts and follow up questions. This type of pattern is directly in line with the Socratic Method. Socratic questioning structure requires the instructor to build question on question, guiding the student to construct their own knowledge.\textsuperscript{9}

The Mastery© program also incorporates techniques that can increase metacognition in students. Metacognition is the idea that students must learn to understand how they learn and process information.\textsuperscript{5} The use of self-reflection as part of a course of study has shown to increase metacognition in students.\textsuperscript{12} Through self-reflection students learn to measure their individual level of understanding. Student ability to measure personal understanding can be aided by completing Mastery© activities. When a student answers a question correctly, they realize that they have a good understanding of the concept addressed in the question. If they answer incorrectly, Mastering© prompts them to discover why the answer was wrong. This can potentially increase metacognition as students reflect on their overall understanding of certain concepts.\textsuperscript{12} The question prompts provided by Mastery© allow the student to revisit the concept and increase their personal understanding.
Mastery© also uses problems to teach course concepts. The use of problems to teach a concept is termed Problem based learning (PBL). This instructional technique relies on the idea that solving problems will lead learners to gain conceptual understanding. Research has shown that using PBL can increase overall understanding of course material because it requires students to think at a deeper level. Problem solving creates deep understanding as the student works toward resolution of the problem. Researchers believe that the problems presented to students serve as a stimulus for the use of reasoning skills that enhance conceptual learning.

Not only can PBL create better understanding of concepts, it is also a preferred teaching method by many students. A recent study showed that students rated a PBL structured course higher than a lecture based course on a preference scale. Student comments also stated that using problems to teach relevant material helped them to enjoy the subject matter more. PBL creates active learning that applies to real life situations; this seems to appeal to students and creates an inner desire to learn a subject. Mastery activities incorporate problems and games into assignments to test understanding of material. Some of the activity sets include matching or labeling activities to teach concepts. One example of this is titled, “How to Build a Better Meal”. Students are asked to assess a pool of menu choices and then drag the best choices into a meal plan. Mastery© also uses questions about case studies to guide students to conceptual understanding. These problems help students engage in the material, hopefully creating lasting knowledge in nutrition based concepts.

Lasting knowledge is sometimes defined as learning retention. Retention of knowledge gain is a concern of many instructors in various fields of study. A key to
enhanced learning retention is student engagement in subject matter.\textsuperscript{16} Student engagement has been discussed as the single most important indicator of course outcomes for individual students.\textsuperscript{16} A recent study explored the use of active learning engagement to assess perceived learning retention.\textsuperscript{17} The participants of this study (n=1,091) were university students enrolled in an introductory psychology course. The students were assigned to an active learning group or to a course review group. The active learning groups were asked to complete assignments in addition to attending lecture.\textsuperscript{17} The course review group attended course review lectures and course lectures.

Each participant was asked to complete an end of semester survey evaluating to what degree students felt they improved on learning objectives for the course. The active learning groups reported significant differences in learning retention (p=<.001) when compared to the course review groups.\textsuperscript{17} This group also reported significant differences in course engagement (p=<.001).\textsuperscript{17} Other studies have conducted similar investigations with similar results.\textsuperscript{18, 19}

Mastery\textsuperscript{©} is a comprehensive teaching tool that reinforces concepts discussed in course readings, assignments, and lectures. This program is intended to create an active, engaging learning experience for students. The objective of this study is to measure increased learning retention in students that used Mastery\textsuperscript{©} as part of the course design. The hypothesis is that Mastery\textsuperscript{©} will contribute to nutrition knowledge and retention of knowledge that will benefit students in the future.
METHODS

Students (n=496) enrolled in an introductory nutrition course were assigned to use an online tutoring program (MasteringNutrition©) as part of the graded component of a blended format course in general nutrition (NDFS 1020). Information was collected over two 15 week semesters (n=86 fall semester, n=410 spring 2014 semester). Prior to study initiation, approval of procedures and informed consent was granted from the Utah State University Review Board. Students were informed of the study during the first class lecture and were given contact information if they desired more details concerning the study. Each student was given the opportunity to participate in a pre-course survey, if they participated they were awarded ten points extra credit in the course.

The pre-survey included ten core knowledge questions (Table1). Each question was written to test student understanding of basic nutrition concepts. Each nutrition concept assessed corresponded to a specific learning objective designed for the NDFS 1020 course. The questions were asked as multiple choice questions. Any student that chose not to take the survey was given other extra credit opportunities. The data from the pre-survey was collected via an online survey format through Canvas.
Students were assigned MasteringNutrition© activities/quizzes on a weekly basis. These weekly assignments were estimated to take the average student approximately 30-45 minutes to complete, however the activities were not timed. This allowed students to finish the assignments at their own pace. Fourteen Mastery assignments were available for students to complete during each semester. The highest twelve scores were used in

| IDEA objective 1a: | Gain FACTUAL KNOWLEDGE (terminology, classifications, methods, trends). Describe the digestion and metabolism of the energy nutrients (carbohydrates, lipids, protein). Once absorbed, all monosaccharides are converted to ________ by the liver. In general, B vitamins function as ________ and are needed for metabolism and energy production.
|
| IDEA objective 1b: | Gain FACTUAL KNOWLEDGE (terminology, classifications, methods, trends). Identify the nutrients needed to maintain health and body function. Be familiar with symptoms of nutrient deficiencies and toxicities. Recognize food sources for each nutrient. Which of the following represent a significant source of vitamin E in the diet? Adequate fluid consumption, carbohydrate counting, restricted intake of simple sugars, daily glucose testing, and weight management are all recommended measures for ________?
|
| IDEA objective 2a: | Learn FUNDAMENTAL PRINCIPLES, generalizations, or theories. Discuss the role of nutrition in relation to health and the prevention of chronic disease. Which of the following statements concerning weight management and fitness is FALSE? Which of the following is NOT a recommendation for healthy weight loss?
|
| IDEA objective 3a: | Learn to APPLY COURSE MATERIAL (to improve thinking, problem solving, and decision-making). Describe what constitutes a sustainable food system and understand the effects of food policy and production on consumers. Compared to food that’s been transported, locally grown foods ______.
|
| IDEA objective 3c: | Learn to APPLY COURSE MATERIAL (to improve thinking, problem solving, and decision-making). Evaluate food quality based on food labeling, nutrition labeling, and food safety practices. You are trying to decide what kind of soup to have for dinner. You have discovered that your diet is often low in iron (a mineral that’s required for proper oxygen transport in the body). Which of the following soups would give you the most iron per kcal? Bean Soup = 3.08 mg Iron (191 kcals) Chicken Noodle = 1.34 mg Iron (117 kcals) Tomato Soup = 1.81 mg Iron (161 kcals) Vegetable Soup = 2.45 mg Iron (96 kcals) The following nutrients are listed in this order on a food label: enriched wheat flour (flour, niacin, reduced iron, thiamine mononitrate, riboflavin, folic acid), partially hydrogenated vegetable shortening, salt, sodium bicarbonate, malted barley flour, yeast. What can you conclude?
|
| IDEA objective 11b: | Learn to ANALYZE & CRITICALLY EVALUATE ideas, arguments, and points of view. Differentiate between credible, science-based sources of nutrition information and unreliable sources. Research findings and results that are ______________ are the most reliable.
|

Table 1: Learning Objectives Used to Categories Questions Used for Pre, Final, and Posttest. (Actual questions used for testing are organized under specific objectives.)

| IDEA objective 1a: Gain FACTUAL KNOWLEDGE (terminology, classifications, methods, trends). Describe the digestion and metabolism of the energy nutrients (carbohydrates, lipids, protein). Once absorbed, all monosaccharides are converted to ________ by the liver. In general, B vitamins function as ________ and are needed for metabolism and energy production. | IDEA objective 1b: Gain FACTUAL KNOWLEDGE (terminology, classifications, methods, trends). Identify the nutrients needed to maintain health and body function. Be familiar with symptoms of nutrient deficiencies and toxicities. Recognize food sources for each nutrient. Which of the following represent a significant source of vitamin E in the diet? Adequate fluid consumption, carbohydrate counting, restricted intake of simple sugars, daily glucose testing, and weight management are all recommended measures for ________? | IDEA objective 2a: Learn FUNDAMENTAL PRINCIPLES, generalizations, or theories. Discuss the role of nutrition in relation to health and the prevention of chronic disease. Which of the following statements concerning weight management and fitness is FALSE? Which of the following is NOT a recommendation for healthy weight loss? | IDEA objective 3a: Learn to APPLY COURSE MATERIAL (to improve thinking, problem solving, and decision-making). Describe what constitutes a sustainable food system and understand the effects of food policy and production on consumers. Compared to food that’s been transported, locally grown foods ______. | IDEA objective 3c: Learn to APPLY COURSE MATERIAL (to improve thinking, problem solving, and decision-making). Evaluate food quality based on food labeling, nutrition labeling, and food safety practices. You are trying to decide what kind of soup to have for dinner. You have discovered that your diet is often low in iron (a mineral that’s required for proper oxygen transport in the body). Which of the following soups would give you the most iron per kcal? Bean Soup = 3.08 mg Iron (191 kcals) Chicken Noodle = 1.34 mg Iron (117 kcals) Tomato Soup = 1.81 mg Iron (161 kcals) Vegetable Soup = 2.45 mg Iron (96 kcals) The following nutrients are listed in this order on a food label: enriched wheat flour (flour, niacin, reduced iron, thiamine mononitrate, riboflavin, folic acid), partially hydrogenated vegetable shortening, salt, sodium bicarbonate, malted barley flour, yeast. What can you conclude? | IDEA objective 11b: Learn to ANALYZE & CRITICALLY EVALUATE ideas, arguments, and points of view. Differentiate between credible, science-based sources of nutrition information and unreliable sources. Research findings and results that are ______________ are the most reliable. |
the computation of grades for the semester and accounted for 12% of the students total grade.

The same questions used in the pre-survey were incorporated into the final exam for the course. These questions were scored as part of the final exam; however students were not informed prior to the final exam. The questions on the final exam were not voluntary as they addressed key concepts and counted towards their final exam score. The numbers of final assessment responses collected by group are presented in table 2.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Mastery fall 2013</th>
<th>Mastery spring 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students enrolled per semester</td>
<td>185</td>
<td>95</td>
<td>408</td>
</tr>
<tr>
<td>Pretest</td>
<td>NA¹</td>
<td>88</td>
<td>393</td>
</tr>
<tr>
<td>Final test</td>
<td>183</td>
<td>85</td>
<td>306</td>
</tr>
<tr>
<td>Posttest</td>
<td>96</td>
<td>65</td>
<td>130</td>
</tr>
<tr>
<td>Posttest % response²</td>
<td>52</td>
<td>68</td>
<td>32</td>
</tr>
</tbody>
</table>

¹Pretest scores for the control group were not available for comparison. Control data was collected after the completion of the course. Pretest information was not gathered for this semester.
²Posttest % response is based on amount of responses gathered out of total enrollment for each section of NDFS 1020 invited to participate in posttest. Total enrollment numbers are as follows: spring 2013= 185, fall 2013=490, spring 2014=408.
In order to assess learning retention, students were asked to participate in a third survey conducted 4-6 months after completing NDFS 1020. Preferred email addresses for each enrolled student were obtained from past course rosters. An email was sent (table 3) to these addresses inviting students to participate in a posttest survey that included the same core nutrition questions. As an incentive, each participant was entered into a drawing with the potential to win prizes. The control group (spring 2013) was the first to be offered the post survey and the following prizes were available: 1- $100.00 gift card, 2- sweatshirts, and 25 ice cream coupons. The treatment groups (fall 2013 and spring 2014) were offered 2-$100.00 gift cards as their prizes. The total responses collected are presented in table 2.

Table 3: Sample Post-Test Email

<table>
<thead>
<tr>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dear Student,</td>
</tr>
<tr>
<td>You have been selected to participate in a research study that focuses on nutrition education. This email is being sent to you because you completed NDFS 1020 (The Science &amp; Application of Human Nutrition) at Utah State University in the fall of 2013.</td>
</tr>
<tr>
<td>To participate, click on the link below and complete the survey. The survey should only take 5-10 minutes to complete.</td>
</tr>
<tr>
<td>Once you have completed the quiz you may enter to win one of two $100 Best Buy Gift Cards! The deadline for participation is Monday March 31st so don’t delay.</td>
</tr>
</tbody>
</table>

After responses were collected, each respondent was given a number in order of submission. These numbers were entered into an online random sequence generator. The first two numbers were contacted through information obtained from the survey.
The students were contacted within a week of survey closure; each winner was given one week to pick up their prize. The results of the post-test survey were analyzed and compared to the collected data from the pre-test and final exam responses.

Data for the control group was generated from existing student test results of the spring 2013 semester of NDFS 1020. This semester did not use Mastering© assignments as part of the course. Two sections of this course took their final exam online. Questions that were similar to the core nutrition knowledge questions used in the assessments described above were selected from the final exam questions recorded. These questions addressed the same learning objectives but were worded differently than the posttest questions used (Table 4). Pretest information was not available for the spring 2013 control group because a pretest was not administered to these students as part of the course design.
Each student that completed NDFS 1020 in the spring of 2013 was asked to participate in a posttest survey administered using the same method described above. They were asked the same questions as the Mastering© groups. Responses were analyzed and used for comparison of Mastering© groups to the control group (table 2).

Table 4: Learning Objectives Used to Categorize Questions Used for Pre, Final, and Posttest. (Actual questions used for testing are organized under specific objectives.)

<table>
<thead>
<tr>
<th>IDEA objective 1a:</th>
<th>Gain FACTUAL KNOWLEDGE (terminology, classifications, methods, trends). Describe the digestion and metabolism of the energy nutrients (carbohydrates, lipids, protein).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All nutrients that provide energy are converted into _____________ before directly entering the TCA cycle. This is often called the “crossroads of metabolism” or the “gateway” molecule.</td>
</tr>
<tr>
<td></td>
<td>Based on the Acceptable Macronutrient Distribution Range (AMDR) for PROTEIN, how many kilocalories should a person consume from protein if his/her Estimated Energy Requirement (EER) is 2,400 kilocalories?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IDEA objective 1b:</th>
<th>Gain FACTUAL KNOWLEDGE (terminology, classifications, methods, trends). Identify the nutrients needed to maintain health and body function. Be familiar with symptoms of nutrient deficiencies and toxicities. Recognize food sources for each nutrient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Which of the following foods would be the POOREST source of folate?</td>
</tr>
<tr>
<td></td>
<td>Which of the following represent a significant source of vitamin E in the diet?</td>
</tr>
</tbody>
</table>

| IDEA objective 2a: | Learn FUNDAMENTAL PRINCIPLES, generalizations, or theories. Discuss the role of nutrition in relation to health and the prevention of chronic disease. Even a moderate reduction in body weight (5 - 10%) can improve the health of overweight individuals. (T/F) Suppose your neighbor gets a blood lipid profile from their physician. If their HDL cholesterol is low and LDL cholesterol levels are high, their doctor (or dietitian) would most likely recommend that they increase _______ fats and to decrease _______ fats in their diet. |

| IDEA objective 3a: | Learn to APPLY COURSE MATERIAL (to improve thinking, problem solving, and decision-making). Describe what constitutes a sustainable food system and understand the effects of food policy and production on consumers. Compared to food that’s been transported, locally grown foods _____. |

| IDEA objective 3c: | Learn to APPLY COURSE MATERIAL (to improve thinking, problem solving, and decision-making). Evaluate food quality based on food labeling, nutrition labeling, and food safety practices. You are trying to decide what kind of soup to have for dinner. You have discovered that your diet is often low in iron (a mineral that’s required for proper oxygen transport in the body). Which of the following soups would give you the most iron per kcal? Bean Soup = 3.08 mg Iron (191 kcals) Chicken Noodle = 1.34 mg Iron (117 kcals) Tomato Soup = 1.81 mg Iron (161 kcals) Vegetable Soup = 2.45 mg Iron (96 kcals) The following nutrients are listed in this order on a food label: enriched wheat flour (flour, niacin, reduced iron, thiamine mononitrate, riboflavin, folic acid), partially hydrogenated vegetable shortening, salt, sodium bicarbonate, malted barley flour, yeast. What can you conclude? |

| IDEA objective 11b: | Learn to ANALYZE & CRITICALLY EVALUATE ideas, arguments, and points of view. Differentiate between credible, science-based sources of nutrition information and unreliable sources. Research findings and results that are _____________ are the most reliable. |
All of the survey/test results for both Mastering© groups were compared to the results of the control group.

Data for Mastering© groups were collected over two consecutive semesters. Data for the pretest given to the Mastering© groups was gathered using an online testing forum administered through Canvas. This data was organized into a spreadsheet and entered into a statistical analysis program. (SPSS) Data for the final test for the Mastering© groups was gathered from scantron results. Targeted questions were identified from test results and input by hand into a spreadsheet. This data was then entered into SPSS. Data for the final test for the control group was gathered from recorded online test submission; the test was given through Canvas. Questions were identified that addressed course learning objectives and responses were recorded into a spreadsheet. This spreadsheet was then entered into SPSS.

Data for the posttests was gathered through two online survey programs. Data for the control group (spring 2013) were gathered in Survey Monkey©. This data was downloaded into a spreadsheet and entered into SPSS. Data for the Mastering© groups was gathered using Qualtrics® surveys. This data was also downloaded into a spreadsheet and entered into SPSS.

RESULTS

The distributions of assessment scores were examined and all were approximately normally distributed. Descriptive statistics of students by group are provided in table 5. Results indicated a change in the percent of questions students got correct for each assessment given. Scores from both Mastering© groups pretest to final test increased
where scores from final test to posttest decreased. The Mastering© groups pretest scores were much lower than those recorded for each group’s posttest results.

<table>
<thead>
<tr>
<th></th>
<th>Control (n=182)</th>
<th>Mastering© (fall 13 n=88)</th>
<th>Mastering© (spring 14 n=393)</th>
<th>P-value¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female %</td>
<td>74</td>
<td>60</td>
<td>70</td>
<td>.087</td>
</tr>
<tr>
<td>White %</td>
<td>90</td>
<td>88</td>
<td>87</td>
<td>.032</td>
</tr>
<tr>
<td>Age % 18-24 years of age</td>
<td>85</td>
<td>82</td>
<td>87</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Pre-test²</td>
<td>NA</td>
<td>.50 (n=88)</td>
<td>.51 (n=393)</td>
<td>.518</td>
</tr>
<tr>
<td>Final test²</td>
<td>.757 (n=182)</td>
<td>.76 (n=85)</td>
<td>.75 (n=306)</td>
<td>.518</td>
</tr>
<tr>
<td>Post test²</td>
<td>.72 (n=96)</td>
<td>.74 (n=93)</td>
<td>.70 (n=130)</td>
<td>.592</td>
</tr>
</tbody>
</table>

¹ANOVA and Chi-squared
²Averages of test responses; high score = 1

Paired sample t-tests were used to examine differences in assessment scores within each semester, (table 6) independent of other semesters or the control group. Significant differences were observed in mean scores by test for fall 2013 pretest to posttest (p=.003). No differences were observed in the fall 2013 final test to posttest (p=.071), and pre-test to final test (p=.194). Significant differences in mean scores by test were also observed for spring 2014; pre-test and final test (p=.<.001), the pre-test and post test (p=.<.001), and the final test and posttest (p=.001).
Table 6: Paired sample t-test results.

<table>
<thead>
<tr>
<th></th>
<th>Pretest to posttest</th>
<th>Pretest to final test</th>
<th>Final test to posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 2013</td>
<td>p=.003 (n=88,93)</td>
<td>p=.194 (n=88,85)</td>
<td>p=.071 (n=85,93)</td>
</tr>
<tr>
<td>Spring 2014</td>
<td>p=&lt;.001 (n=393, 130)</td>
<td>p=&lt;.001 (n=393,306)</td>
<td>p=.001 (n=306, 130)</td>
</tr>
</tbody>
</table>

A repeated measures analysis was conducted to assess the group by score over time effect between both Mastery groups and the control group. Comparison between Mastering© fall 2013 and Mastering© spring 2014 were non-significant, p=.677. Comparison between both Mastering© groups and the control group was non-significant, p=.287. Figure 1 is a graphical representation of the measured effect of each group. Student test scores tended to be highest on the final test and decrease on the posttest.
Results of a chi square analysis for categorical variables are presented in table 5. Age, gender, and ethnicity differed by group, these variables were included as covariates in the repeated measures described above as analysis of covariance. In addition, to examine whether these factors mediated the association between assessment score and group, the interaction term for these covariates and the assessment score over time were included in the model. None of these interaction terms were statistically significant indicating that the effect of score over time did not depend on group assignment, gender, age, instructor, or ethnicity of the study participants. P-values reported include; test scores*instructor .502, test scores*race .186, test scores*age .651, tests scores*gender .333.

A repeated measures analysis was conducted using a split variable. Participants were divided in to two groups depending on how they scored on the pretest; group one included students that scored above average and group two included the students that scored below average. There was a significant statistical difference in test scores between these groups as well, p=<.001. Suggesting that students that used the MasteringNutrition© program were able to increase basic nutrition concepts over the duration of the NDFS 1020 course. This increase in basic nutrition knowledge allowed the below average group to demonstrate test scores comparable with the above average group by the end of the course. Figure 2 shows graphically the change in student test scores over time according to group.
DISCUSSION

MasteringNutrition© was not successful in improving individual student outcomes when compared to the control group outcomes in NDFS 1020. Because the use of MasteringNutrition© did not create a significant change in student scores over time the use of Mastering© as part of course structure should be reevaluated.

The MasteringNutrition© tutorial was created using similar models previously implemented and tested by several universities across the United States. The data presented by Pearson on MasteringBiology© is the closest comparison available, both biology and nutrition are life sciences, for the MasteringNutrition© program. Pearson’s white paper discusses nine studies centered on MasteringBiology©. Each study reported significant improvements in student scores when Mastering© was used as a course supplement. Improvements on test scores ranged from 1 or 2% increase to 25%
increase. The majority of the studies were conducted over the course of 2-5 years.\textsuperscript{20} Eight of the nine studies used overall means of exam scores and class grades to determine the effect of Mastering©. All of the studies reported significant improvements in letter grades and final test scores.\textsuperscript{20} One study used a posttest follow up to assess the amount of learning students had retained after completing the course. Mastering© students achieved higher posttest scores than students who did not use Mastering© \textit{p}=.025.\textsuperscript{20} Other papers have been published concerning MasteringBiology©. These papers use similar designs as described above, using overall exam and course scores to assess benefit.\textsuperscript{21,22} There is currently no research available that tests MasteringNutrition© exclusively.

The evidence of success using Mastering© programs has been well documented by Pearson, the results of our study are inconsistent with these results. This can be explained partially by differences in the way that learning was assessed in these studies compared to this study. The studies cited by Pearson used comparisons of overall grades from established courses over several semesters or years. Our study looked at the improvement of students on specific, core knowledge questions, instead of general letter grades or exam averages. We used these core knowledge questions in order to control for students that began the class with little to no knowledge of nutrition concepts. We ran an analysis of collected test scores for each individual student splitting them into below average and above average categories. We found that the students that scored lowest on the pretest improved in test scores by 35\% by the final test. In comparison, students that scored higher on the pretest improved by 10\% on the final test.

It is possible that Mastering© did improve overall test scores and grades for NDFS 1020, however, these were not the primary outcomes of the study described here.
The objective of our study was to test the increase in student understanding of basic nutrition concepts and how much knowledge students retained after completing the course.

The results reported in this paper improved in question response from the pretest to the final test; this suggests that student understanding of concepts did improve during the duration of the course. We observed a decrease in student scores from the final test to the posttest given, but the posttest scores were higher than the pretest scores for each Mastering© group. This suggests that students did gain and retain conceptual knowledge introduced to them through the NDFS 1020 course. Learning retention was indicated for both Mastery groups and the control group. Posttest scores for all groups were higher than each corresponding pretest scores. There was no difference observed in increased learning retention for the Mastery© groups when compared to the control groups. This indicates that learning of defined objectives is occurring and being retained, but is not affected by the Mastering activities.

One strength noted by researchers was the effect Mastering© had on students that entered the NDFS 1020 course with less knowledge. Students that scored lower on the pretest tended to gain more knowledge during the course when they used the Mastering© program (figure 2). In fact, below average pretest scores improved to be comparable to the above average student’s final exam scores. One benefit of the Mastering© tutorials may be the ability to help students gain fundamental nutrition knowledge they may be lacking. The benefit of Mastering© may not be as noticeable for students that already have fundamental nutrition knowledge when they enter the course.

The population of our sample was largely young (18-25 years of age), white, females. This creates a bias in our sampling and limits our ability to make general
conclusions regarding older students and male students. Potential bias of categorical variables was significant when chi square analysis was conducted. In order to address the potential for statistical bias in our sample, a repeated measures analysis was conducted. The results of the repeated measures analysis indicated non-significance across all variables. Analysis did not suggest that any statistical bias existed in our sample.

The percent student response rate for each posttest given was lower for each Mastering© semester than the control group. Due to the small sample size of posttest responses in Mastering© groups there may be some conditions of bias in the results. When data was analyzed to discover potential bias, it was noted that students that earned a high score in the course overall were more likely to take the posttest. We attempted to get a larger sample of posttest responses for the Mastery spring 2014 group by extending the length of the availability of the posttest. This was not successful in generating a higher response rate. However, the population of students that took the posttest were not statistically different in a repeated measure analysis (p=.71).

Some problems with data collection were experienced over the course of this study. A change in how the final exam was administered in NDFS 1020 caused pertinent data to be lost. Final exams had previously been given through an online format; administrators changed this to a paper base format where students recorded responses on a scantron sheet. This new format created difficulty in gathering final exam data for each Mastering© group. Three sections of fall NDFS 1020 final exam data were unavailable due to data collection errors on scantrons. This explains why the amount of posttest responses collected was larger than the final exam scores used for data analysis. Also,
some data was missing from final exam responses for spring 2014. However, the amount lost was minimal when compared to losses seen for the fall 2013 group.

The implementation of Mastering© into NDFS 1020 did not create the effect expected by course administrators and researchers. Mastering© did not increase student conceptual understanding according to our research. Review of conducted analysis did reveal that MasteringNutrition© could be a valuable resource for students that lack basic nutrition concept understanding. Because of Matery’s© potential to help entry level students have greater success in the course, continued use of this tutoring program is suggested.

REFERENCES


CHAPTER IV

IMPLICATIONS OF STUDY RESULTS CONCERNING ONLINE TUTORING PROGRAM IN ENTRY LEVEL NUTRITION COURSE.

ABSTRACT

Objectives: To assess current NDFS 1020 course structure using data from recent study concerning effectiveness of MasteringNutrition© tutorial program.

Methods: Evaluation of MasteringNutrition© conducted using evidence documented in previous studies.

Results: MasteringNutrition© is a program similar to other tutoring or active learning programs that have been successful in other course structures. MasteringNutrition© program failed to produce expected results in increasing student assessment scores in NDFS 1020 over the course of two consecutive semesters. A positive effect was observed with the use of Mastering© in students that scored below average on course pretest.

Discussion and Implications: MasteringNutrition© as a component of NDFS 1020 did not produce desired effect in overall assessment scores. However, MasteringNutrition© may be beneficial to students that enter NDFS 1020 with a low level of basic nutrition knowledge.

REFLECTION

The results of our study concerning the MasteringNutrition© online tutorial program were not expected. Much research and investigation was conducted to justify the implementation of MasteringNutrition© as a graded component of an entry level
The nutrition course, NDFS 1020. The average enrollment of the on-campus sections of NDFS 1020 at Utah State University is approximately 300 students. Students are enrolled in sections that are capped at 100 students. Enrollments for the past 5 years are listed in Table 7. The large amount of student interest in this course creates a demand for excellent teaching methods that are tailored to help each student succeed.

Table 7: Enrollment Data for NDFS 1020 from 2009-2013

<table>
<thead>
<tr>
<th>Year</th>
<th>Spring Semester</th>
<th>Fall Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>423</td>
<td>395</td>
</tr>
<tr>
<td>2010</td>
<td>468</td>
<td>294</td>
</tr>
<tr>
<td>2011</td>
<td>298</td>
<td>300</td>
</tr>
<tr>
<td>2012</td>
<td>360</td>
<td>383</td>
</tr>
<tr>
<td>2013</td>
<td>450</td>
<td>486</td>
</tr>
</tbody>
</table>

The research published by Pearson assessing the impact of their discipline specific Mastering© programs, provides evidence that Mastering© improved student performance in courses that implement the Mastering© programs. The results of these studies are based on final test scores and overall letter grade achievement by students. The design for our study used ten core nutrition questions to test improvement in course knowledge, instead of looking at overall test score and letter grade improvement. The results of our study were inconsistent with Pearson’s reports of
improvement in test scores when Mastering© was implemented into course structures. In the case of NDFS 1020, implementing Mastering© did not result in improved test scores.

Educational research also supports the use of programs like MasteringNutrition©. Active learning programs, similar to the MasteringNutrition© program, attempt to incorporate instructional methods that have been proven to increase student understanding and knowledge retention.⁴,⁵ These active learning programs reported significant changes in test scores between active learning groups and control groups, p=<.0001. Instructional techniques, for example Socratic questioning and problem based learning, also support the use of the types of questioning and problems seen in Mastering©.⁶,⁷ However, our study did not support the results seen in these various studies. It is possible that the MasteringNutrition© program is not as effective as other methods because it is an online format instead of a personal or group experience.

Without evidence that MasteringNutrition© improves student learning outcomes, it is difficult to justify the continued use of this platform in the course for several reasons. MasteringNutrition© is costly to the student. Individual student fees for the NDFS 1020 course are increased by ~$75 per semester. This fee includes the MasteringNutrition© tutorial, an online textbook, and access to the MyDietAnalysis© program. The amount of fee increase may not be extremely high, but it does impact the student financially. Also, MasteringNutrition© assignments are costly to student time. Time is required to complete the assigned activities/quizzes, this time could be better spent studying in an alternative way if Mastering© assignments were not required and not productive to increased understanding.
Our study did produce some evidence that suggested Mastering© assignments helped students with lower entry level nutrition knowledge gain basic nutrition concepts over the duration of the course. This gain in entry-level knowledge helped these students increase their test scores to be similar to students with higher entry level knowledge. Mastering© could potentially help students that have little to no nutrition knowledge be more successful in NDFS 1020. Allowing students to use Mastering© on an as needed basis may be a better use for the program than as a requirement for all students in the course.

REFERENCES


