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Assessing the Effectiveness of Student Oriented Learning Outlines (SOLOs) In an Equine Classroom

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ABSTRACT

This study determined if the use of the student oriented learning outline (SOLO) in a University of Arkansas equine production classroom had a positive influence in three areas: mastery of material taught, retention of material taught and voluntary positive student behaviors related to the use of course material. Thirty-one students who were enrolled in 2012 were in the non-SOLO group (control), and 25 students who were enrolled in 2013 were the SOLO group (treatment). Three separate units were taught to the treatment and control groups with only one difference: the treatment group was given a SOLO one week in advance of three equine production labs.

Lab exam scores on three units taught with and without SOLOs were compared utilizing Analysis of Covariance (ANCOVA). ANCOVA was used to statistically control for any effects due to differences in high school grade point averages of participants. On two unit exams, the SOLO group significantly outperformed the non-SOLO group. On the third unit exam, the difference between the SOLO group and non-SOLO group was not statistically significant.

When students anonymously responded to statements concerning SOLOs, their perceptions were overwhelmingly positive, underscoring the fact that the students found the SOLOs beneficial in preparing for exams and a useful guide for what should be learned.

Positive affective indicators of voluntary student behavior were exhibited in each of the three SOLO labs; this demonstrated that students not only gained knowledge and skill but also continued to voluntarily use the knowledge or demonstrate the skill, because they believed it to be worthwhile.

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I would like to acknowledge the support and contribution of members of my committee and the time that they willingly spent to help me to achieve my goal. Dr. Hammons taught me so much about course design and how to effectively teach – and then he spent countless hours as my Chair, reading my work, meeting with me and providing outstanding feedback. He is truly dedicated to the students he mentors, and I am so grateful for his time. I am grateful for the input offered by Vice Provost Suzanne McCray and particularly appreciative of her excellent editing skills. I am indebted to Dr. Donald Johnson who freely gave his time and expertise to guide me through statistical problems that I encountered, while also providing valuable feedback.

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I would like to acknowledge all of the people who have cheered me on and supported me, especially Carl and Jan Collier, Marci Crosby, Sandy Hamm, Lauren Aday, Liz Diehl, Jan Knighten, Carol Thompson, Dr. Nancy Jack, and my students.

DEDICATION

I would like to dedicate this dissertation to my sister, Dr. Karen Jogan. I would have never embarked on this project, or realized that my completing a doctorate was even a possibility without her unwavering support, guidance and faith in me.

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I. INTRODUCTION

Context of the Problem

Stakeholders in higher education demand improvement in the quality of education (Education Commission of the States, 1995; National Survey of Student Engagement, 2001). These expectations are warranted because of the knowledge and skills graduates will need to achieve successful careers in our information-based global society (Kuh, 2001). Land grant institutions such as the University of Arkansas are under enormous legislative and stakeholder pressure to improve student retention rates, especially in the science fields (McShannon et al., 2006). Resources in the form of capital, laboratory facilities and faculty time are expended educating students in these fields, and when students either do not graduate or switch majors, this investment is lost. The Office of Institutional Research (IR) at the University of Arkansas reports that only 50% of the 2007 incoming freshman majoring in animal science graduated within six years with a Bachelor of Science in animal science.

There are a number of factors that influence student retention. Three factors that faculty members should be concerned with are external factors affecting students, student characteristics, and the role faculty members play in the educational process and student retention. These factors meld together, and faculty should be cognizant of the interplay between them.

External Factors that Affect Student Success

Some of the external factors that are related to lower student performance in the classroom and ultimately retention and student success are beyond the control of faculty or students. These factors include low socioeconomic status, low GPA in high school, ethnicity, and inadequate preparation while in high school (O'Keeffe, 2013; Tinto, 1987). Other external factors affecting

student success include student characteristics, financial issues, unwillingness to ask for help, and stress. Some of these are factors that institutional policies and procedures can address (Astin, 1993; Tinto, 1987).

Student Characteristics

Two factors influencing student success are the characteristics of today's students and the ways today's college students use their time. Utilizing data obtained from The Education Trust, Greene and Forster (2003) determined that more than half of the students who graduated from high school entered college, yet many were unprepared for college level academics. Greene and Forster (2003) also reported that 32% of students who graduated from high school possessed the bare minimum qualifications needed to apply to college. Unfortunately, while problems stemming from underprepared students who enter institutions of higher education concern faculty, there is little that faculty can achieve if prerequisite courses are not available or required.

In addition to not being prepared for college, many of today's undergraduate students are pressed for time. Mortenson (2011) examined the survey results of 880 students who participated in the American Time Use Survey (ATUS) from 2003 – 2009. The ATUS was administered by the Bureau of Labor Statistics and determined how much time during the week full-time college students spent on educational activities. As can be seen in Figure l, Mortenson found that students spent only 3.3 hours per weekday attending classes, studying, doing homework and participating in research and working full or part-time jobs. In 2011, the National Center for Education Statistics gathered information from 16 – 24 year old undergraduates enrolled in institutions of higher education. They reported that in 2011, 74% of part-time undergraduates and 41% of full-time undergraduates worked (National Center of Education Statistics, 2013). Of the full time undergraduate students in 2011 who worked, 16% reported

working less than 20 hours per week, 18% reported working 20 – 34 hours per week and 6% reported working 35 or more hours per week (National Center of Education Statistics, 2013). Of the part-time undergraduate students in 2011 who worked, 11% reported working less than 20 hours per week, 28% reported working 20 – 34 hours per week, and 33% reported working 35 hours or more per week (National Center of Education Statistics, 2013). These statistics are in sharp contrast to undergraduate employment information reported in 2000. It should, however, be pointed out that students who are enrolled in the University of Arkansas' Bumpers College of Animal, Food and Life Sciences (AFLS) may work more hours per week than the average student enrolled in college. Recent figures show that AFLS seniors average 3.004 hours per day working, making the amount of time that they work 15.02 hours per week (National Survey of Student Engagement, 2013); this is in contrast with the 13.0 hours per week students spend working as reported by Mortenson (2011).

Nationally, a smaller percent of undergraduate students, ages 16 – 24, were working in 2011 than in 2000. In 2000, 52% of all undergraduates were employed, compared to 41% in 2011 (National Center of Education Statistics, 2013). Most notably, there was a decrease between 2000 and 2011 of the percentage of part-time students who worked 35 hours or more per week; in 2000, 47% of all part-time students worked 35 hours per week compared to 35% in 20ll (National Center of Education Statistics, 2013).

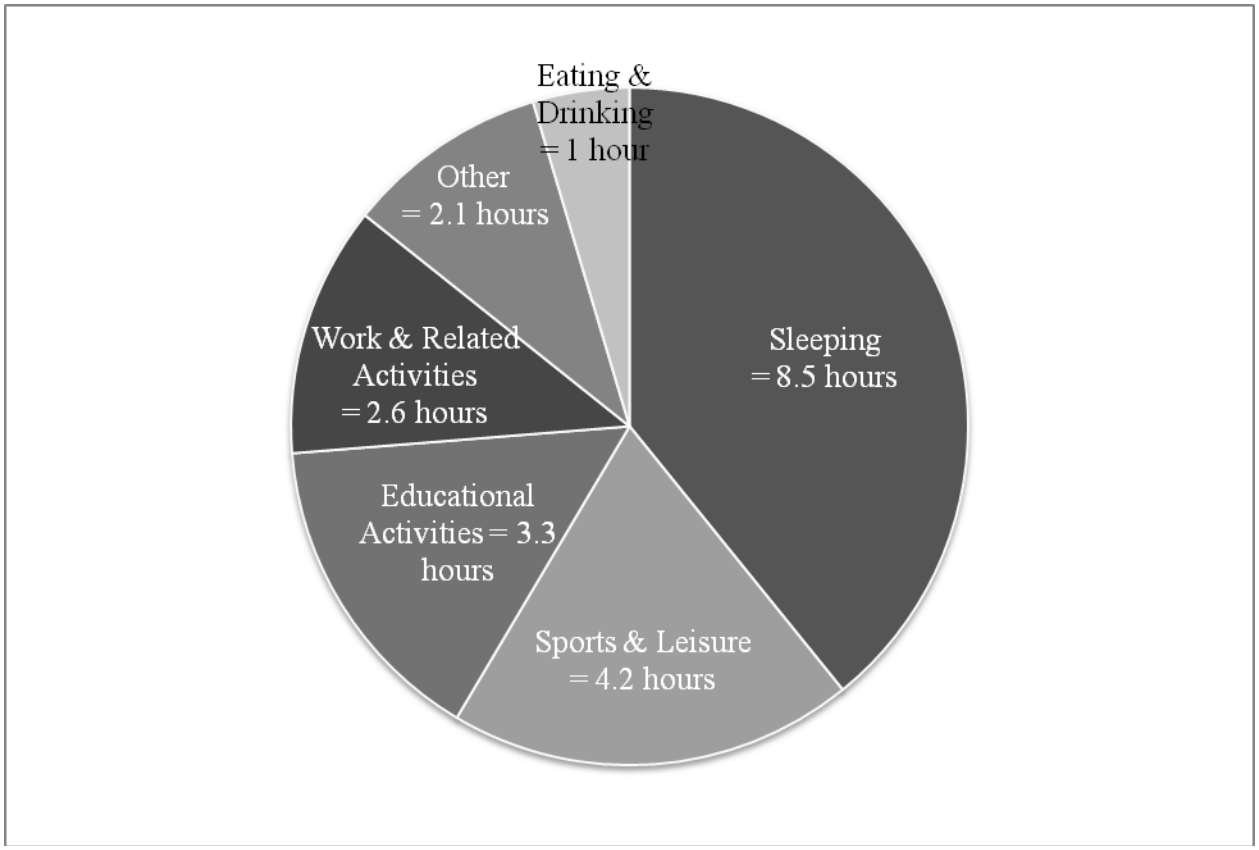

Figure 1. The Student Time Clock: How Typical College Students Spend their Weekday From "Time use of full-time college students on weekdays ages 18 - 24 2003 – 2009." by T. G. Mortenson, 2011, *Post Secondary Education Opportunity, 223*, p. 1.

Another major difference in how undergraduates of today differ from students of the past is the amount of time today's students spend social networking. As an illustration, a 2009 study of 92 undergraduates reported that students averaged 30 minutes per day on Facebook (Pempek, Yermolayeva & Calvert, 2009). In a more recent study Huang and Capps (2013) investigated how college students spent their time on conventional and academic reading. Participants in this study consisted of 1,265 college students enrolled at a public arts university in the southwestern United States, and results revealed that students spent 7.72 hours per week on academic reading, 4.24 hours per week on recreational reading and 16.13 hours per week on social networking sites (Huang & Capps, 2013). The results of this study confirmed earlier studies indicating that

students spend more time on social networking sites than they spend on recreational reading and academic reading combined (Mokhtari, Reichard, & Gardner, 2009). Naturally, time spent working and participating in social networking means less time available for students to participate in educational activities.

In another article, Babcock and Marks compared how much time full-time college students in 1961 spent on educational activities with the amount of time students devoted to those activities in 2003. Full-time college students in 1961 spent 24 hours per week on educational activities while full-time college students in 2003 spent 14 (Babcock & Marks, 2011). The Higher Education Research Institute (2003) reported that in 1987 students claimed they spent six or more hours per week studying outside of class, and that this number has steadily declined since 1987 (Higher Education Research Institute, 2003). The old adage of spending two hours for every one hour in class (Cornell College, 2013; University of Oregon Teaching and Learning Center, 2013) does not apply to many of today's college students. They either do not have the time, or are unwilling to spend their time on educational activities. Over the past several decades, college students are spending less time studying. Winship, a professor at Harvard, believes that reduced time studying has, in part, led to a faculty-student low-low contract (Winship, 2011). Winship (2011) feels that students have low expectations of being taught, and faculty have low expectations of students studying.

Searching the phrase "student sense of entitlement" in the print media provides the following results: in 1996 this phrase was used 16 times, in 2006, 102 times, and between the years 2007 and 2009, 477 times (Baer & Cheryomukhin, 2011). Greenberger et. al (2008) directly relates student entitlement to the grades students think they deserve. One reason cited for this jump in focus on student entitlement is that college students can impact faculty merit and tenure through

student evaluations (Caruth & Caruth, 2013, p. 108). The concept of Academic Entitlement (AE) is defined by Greenberger et al. (2008) as "expectations of high rewards for modest effort, expectations of special consideration and accommodation by teachers when it comes to grades, and impatience and anger when their expectations and perceived needs are not met" (p. 1194). The role of the student in college has changed. College students, along with administrators, parents, accrediting commissions, government oversight and funding bodies are stakeholders and consumers of higher education. One area in which students in their role as stakeholder exert influence is in grading practices. Caruth and Caruth (2013) report that a grade-leniency theory exists. These authors state "students buy good grades and faculty buy good evaluations in return" (Caruth & Caruth, 2013, p. 108).

Vedder (2010) claims that most of the grade inflation has occurred since student evaluation of faculty began. Caruth and Caruth (2013) caution that grade inflation has created an upward shift in grades without the corresponding upward shift in knowledge. Young explains that over reliance on student evaluation of faculty has negatively impacted the quality of education, because students are not in a position to properly assess faculty competence, and that student evaluations of faculty are often a better measurement of popularity than competence (Young, 1993). Student evaluations are used as a measure of faculty competence and performance and have an impact on tenure, promotion or merit pay decisions (Centra, 1979). Unlike students of past generations, today's students evaluate faculty members, and the evaluations have an impact on grading practices, education quality and even faculty promotion decisions.

Today's students also differ from students from the past in other ways. Today's undergraduates need direction to determine what is important to learn, and they desire structure in the classroom (Crone & MacKay, 2007). This fact was clearly stated in a 2007 article by

Crone and MacKay, entitled *Motivating Today's College Students*. The authors stated "we have also become aware that students increasingly seek someone to provide structure, direction, and praise in a way other generations did not" (Crone & MacKay, 2007, p.19).

It is important for faculty to understand the amount of time that college students allot for educational activities and their desire for structure. Actions by faculty to maximize the effectiveness and efficiency of students' time on task will help. The Student Oriented Learning Outline (SOLO) is one approach that takes these student characteristics into consideration by making learning more effective and efficient.

The Role Faculty Members Play in the Educational Process and Student Retention

In an often cited article for *The Journal of College Student Retention*, Braxton and Mundy (2002) identified 47 recommendations that they viewed as levers to reduce student departure from higher education and listed them by the stakeholders who should implement them. Of these 47 recommendations, only fifteen could be affected directly by faculty (Braxton & Mundy, 2002). However, as Braxton and Mundy (2002) pointed out, faculty members play a crucial role in student retention, and should do what they can to help students succeed.

A more complete list of factors affecting student success is contained in the C^5AMEO^2 Model shown in Figure 2 (J. O. Hammons, HIED 6323 lecture, October, 2009). The outer ring of the model, outside environment, is outside of the control of faculty. The second ring of factors, organizational culture (the way things are) and climate (the way students and faculty feel about it) are determined by the people, policies and procedures at the program, department, division or institutional level. Many of these factors, although important in determining student success cannot be directly influenced by individual faculty actions.

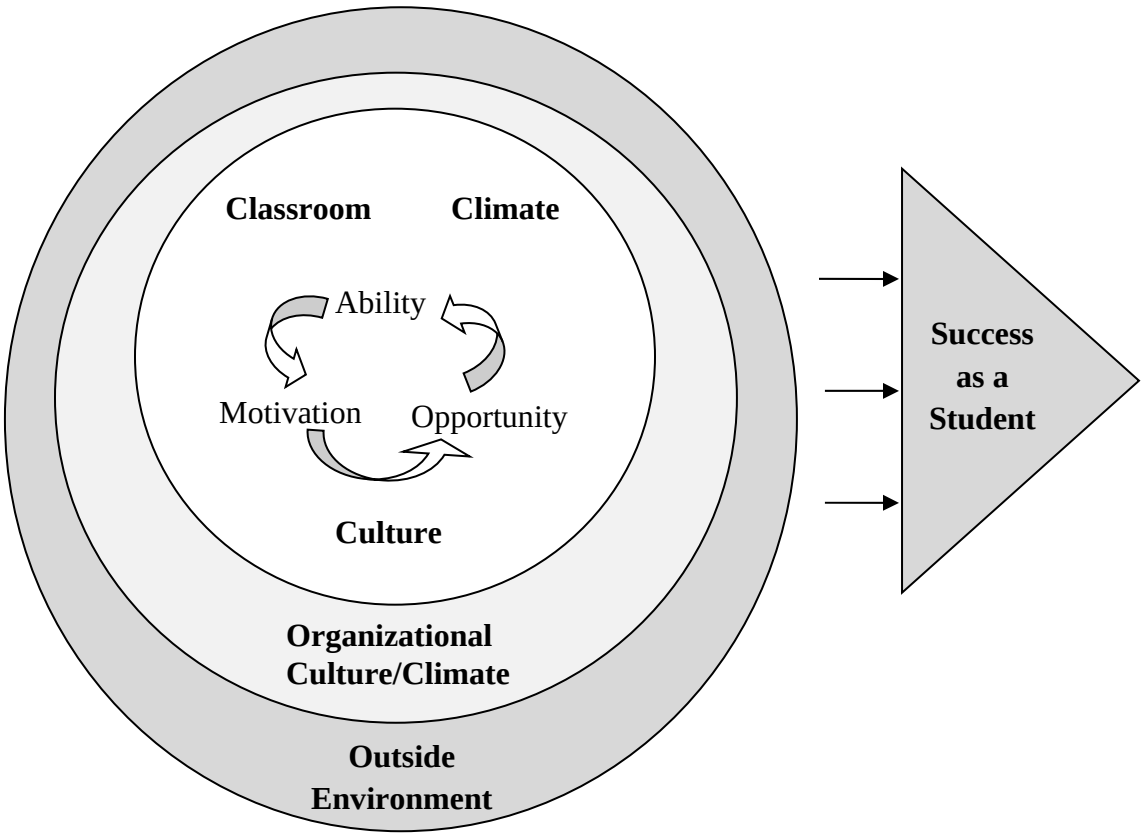

Figure 2. C^5AMEO^2 Model of Factors Affecting Student Success. From Hammons, 1975, with permission of the author.

Fortunately, the next ring of factors, classroom culture and climate, are largely under the direct control of faculty. Faculty members can develop clear unit objectives, provide transparent grading systems with rubrics, state convincing reasons why learning objectives are important, include pre-assessments to determine student readiness, identify efficient and effective ways for students to master each objective, and develop objective-referenced assessment measures and a learning oriented environment that reduces the need for students to cheat (Gallant, 2008). The proper development of course materials positively affects student motivation (Entwistle, 2003) and student motivation determines the success of a learning activity (Cole, Feild & Harris, 2004). Motivating students results in a classroom where students, whatever their ability, are motivated to spend time on task.

Ability, motivation and opportunity are intertwined. Through the use of pre-tests and prerequisites, faculty can make sure that students possess the entry knowledge, skills and abilities they need to succeed. Using non-graded formative assessments prior to testing for grading purposes also allows faculty members to determine where students had problems and where they need to provide assistance, thus ensuring that more students succeed.

The opportunity for students to demonstrate their ability and apply what they have learned is a key factor in student learning and engagement (Pascarella & Terenzini, 1991). Faculty should also seek to find ways to increase learning efficiency by improving the gains-to-effort ratio (Hu & Kuh, 2003). Simply put, the gains-to-effort ratio in the context of learning efficiency means that faculty should design instruction so that students can maximize learning with the least amount of input. This idea comes from the economic principle of efficiency. If the effort and time that students spend on task is a critical factor determining student learning, faculty can increase student success by making every minute that students are in class or studying count (Groccia & Miller, 2000; Hu & Kuh 2003). One learner-centered approach to teaching that has been shown to have a positive influence on student motivation to learn is through the use of the Student Oriented Learning Outline (SOLO).

Statement of the Problem

Since admission standards were raised in 1997, the characteristics of students in animal science and equine science have changed at the University of Arkansas. In the past, students who were seeking a degree in animal science were typically male and came from an agricultural background. Many of these students sought to obtain a degree and then return to the family-owned farm.

Many of today's students are quite different. Undergraduate students majoring in animal science with a concentration in equine science often have little or no experience with livestock. University of Arkansas students were part of a 2013 national survey of undergraduates enrolled in equine programs representing 20 colleges and universities. Of the 862 undergraduates who participated in the survey, only 19.5% described their "home town" as rural and only 22% said that they had "a lot of knowledge about horses" (Bump, 2013). Like many other undergraduates these students have (or are willing to spend) a limited amount of time on educational activities. As pointed out earlier, they will benefit when guided by faculty who direct attention to what is important.

Undergraduate equine students are not alone in needing guidance. Faculty need guidance as well because many have not been trained in developing courses systematically, and thus "can't do what they don't know *how* to do" (Hammons, 2011a). Being clear about objectives and providing a roadmap showing students how to master objectives is important for both students and faculty. An approach to instruction built around Student Oriented Learning Outlines (SOLOs) offers a strategy that would meet the needs of both faculty and students in achieving the common goal of student success.

Purpose of the Study

The purpose of this quantitative study was to determine if the use of SOLOs had a positive influence in three areas: mastery of material taught, retention of material taught and voluntary positive student behaviors related to the use of course material.

Research Questions

The following research questions guided the study. For University of Arkansas students enrolled in an equine production course:

1. After controlling for student high school grade point average, was there a significant difference in student performance on each of three exams between students taught using SOLOs and students taught using traditional methods?
2. To what degree do students taught using SOLOs retain the material covered, as measured on unit exams?
3. Are SOLOs rated by students as useful to them in preparing for exams or in helping them to determine what they were expected to learn?
4. For each unit taught using SOLOs, voluntary affective indicators of behavior were collected. Is there evidence of voluntary positive student behaviors related to the goals of the SOLO unit? (explained more fully under methodology)

Significance of Study

As pointed out earlier, institutions such as the University of Arkansas are under constant pressure to improve retention rates of all students. A part of the responsibility for improving student retention rests with faculty members. One way faculty can improve retention rates is to use effective teaching strategies that result in more effective and efficient student learning. This will be helpful to students, but will be especially helpful for students experiencing time pressures.

The SOLO is a systematic approach to teaching that begins with unit topics, derives general learning goals from these, provides a convincing rationale for learning, and, for each learning goal, provides specific learning objectives. It then tells students effective ways to learn each

objective and furnishes them with a non-graded means of determining if they have learned – prior to being evaluated for grading purposes. Results from this study could provide faculty with an effective method of instruction that not only would increase student time on task but ultimately increase retention rates.

Definition of Terms

To ensure consistency, and because many terms used throughout the study are often defined differently in the literature, definitions for often used terms are defined below. As a consequence, they will not need to be defined again.

1. *Affective indicators:* An affective indicator is a voluntary student behavior which demonstrates that students not only have gained knowledge and skill but are continuing to voluntarily use the knowledge or demonstrate the skill because they believe it to be worthwhile. Affective indicators are best collected unobtrusively and anonymously (Hammons, 2011a).
2. *College students of today (or today's student):* Students who are Millennials or Generation Y. They were born between 1984 and 2002 (Holm, 2012).
3. *Criterion-referenced evaluation:* Criterion-referenced evaluation occurs when grades are based on comparisons against a standard and not the performance of other students. This form of evaluation indicates what a student has learned, not how the student compares to other students (Hammons & Barnsley, 1992).
4. *Curriculum:* Curriculum is that which answers the question "what should be learned?" (J. O. Hammons, HIED 6323 lecture, October, 2009).
5. *Formative evaluation:* Formative evaluation is evaluation that serves two purposes; it provides feedback to students so they know how they are doing prior to being tested

for grading purposes and it provides feedback to instructors so they can identify trouble spots and offer additional learning resources or change teaching methods to improve student learning (Hammons, 2011a). In the SOLO approach, formative evaluations are called post-tests or self-quizzes.

6. *Pre-test:* A pre-test or pre-assessment can serve three purposes: (a) It can test prerequisite knowledge and skills needed for student success when learning a unit; (b) it can test present knowledge about the topic; (c) in some instances, pre-tests can act as a baseline, against which end of the unit achievement can be measured (Hammons, 2011a). Regardless, pre-tests should be based on the knowledge and skills required by unit objectives.
7. *Summative evaluation:* Summative evaluation is evaluation used for grading purposes at the end of a unit for determining the extent to which students have mastered the stated objectives (Hammons, 2011a, p. 195). A post-unit test, midterm or final exam are commonly used approaches for summative evaluation.
8. *Learning goal:* A goal is a broad, general statement of intended outcomes in skill, knowledge, or attitude (Hammons, 2011, p. 43). Goals are usually stated so generally that two or more instructors might experience difficulty selecting learning materials or designing the same learning activities to achieve them; they might also disagree on the assessment measures for evaluating the results of instruction, and finally they might disagree about whether-or-not the students had demonstrated mastery (J. O. Hammons, HIED 6323 lecture, October, 2009). Examples of verbs used when writing goal statements are “understand” and “be familiar with.”

9. *Learning objective:* A learning objective is a written statement that communicates what students should be able to do when they have successfully completed a learning experience (Hammons, 2011b). Learning objectives are stated in terms of measurable, observable and demonstrable actions. Where appropriate, learning objectives may include conditions under which students should perform the desired outcome (time boundaries, materials available, etc.). In some instances, learning objectives should include the criteria for judging student performance (Hammons, 2011, p. 43). Simply put, a learning objective communicates *what* the learner will be able to do, and, if appropriate, the conditions under which the learner to be able to do it and *how well* it must be done. Examples of verbs used in writing objective statements include "write", "summarize" and "evaluate."
10. *Mastery learning:* Mastery learning is a research-based philosophy of instruction based on the assumption that under appropriate conditions most students can learn at levels previously thought obtainable by only a small percentage of students. A mastery learning course is oriented toward desired terminal performances, and instruction focuses on individual student performance not class performance. The instructor's primary role becomes that of a learning manager. A student's performance is evaluated by comparing it with an absolute standard in which grading is based on achievement of objectives, not on the comparison of one student to another. (J. O. Hammons, HIED 6323 lecture, October, 2009).
11. *Objective referenced evaluation:* Objective referenced evaluation is an approach to assessing student learning in which tests and other evaluation instruments are based

on course objectives (adaptation from Van Horn, 1989). Objective referenced formative and summative evaluations are necessary components of SOLOs.

12. *Time on task:* Time on task is the amount of time that the student is actively engaged in the learning process. Time on task, the quality of time spent learning and the amount of time allocated for learning are components of student achievement (Florida Education Association, n.d.; Stallings, 1980).
13. *Rationale:* Rationale (sometimes called advance organizer) is a framework given to students prior to the start of a unit. The rationale statement serves the following purposes: it identifies and communicates to students the importance of learning the information; it helps students see the value of the unit; and it places the unit in the context of previous units and/or future goals. A well crafted rationale statement should be interesting, simple, and a 'sales pitch' for the unit (Hammons, 2011a, p.154).
14. *SOLO:* A Student Oriented Learning Outline is a written document for a specified unit of instruction that is given to students. It usually contains learning objectives describing what the students will be able to do when they have successfully completed the learning experience, and a pretest which serves three purposes: (a) it lets students know how much they already know, (b) it lets students know if they have the requisite skills to successfully complete the unit, and (c) it allows the instructor to identify the level of present skills and knowledge of each student. Creating a SOLO requires the instructor to identify effective and efficient ways students can learn each objective. In most units a SOLO may also contain an ungraded post-test designed to assess student mastery of each objective. In

> developing a SOLO, faculty usually begin with a topic, then for each topic they develop one or more learning goals, then they develop measurable specific learning objectives based on these goals. In short, a SOLO tells students what they are to learn, how they can learn it, and when they have learned it (J. O. Hammons, personal communication, February 1, 2014).

Chapter Summary

In Chapter I, external factors that affect student success, student characteristics and how faculty can influence student retention were discussed. This discussion set the stage for an explanation of the purpose of this study. One systematic approach to instruction that would meet the needs of both faculty and students in achieving their common goal of student success is the Student Oriented Learning Outline (SOLO). Research questions were provided along with the significance of this study and the potential benefits derived from providing faculty with an effective method of instruction. This chapter ended with a definition of terms that will be used in the study.

II. REVIEW OF THE LITERATURE

Literature Search and Review Process

Searching for articles specifically linking Student Oriented Learning Outlines (SOLOs) to equine science proved unfruitful. After a thorough search utilizing the University of Arkansas search engines, I am satisfied that there has been no research conducted to date utilizing SOLOs in equine science.

When searching using the key words *SOLO* or *Student Oriented Learning Outline,* a small number of dissertations, journal articles, and unpublished manuscripts were found. The bibliographies of these articles and dissertations yielded additional sources, some of which described the underlying constructs of SOLOs. Because SOLOs were first developed in the early 1970s, I began my review with literature dating from 1970. Dr. James Hammons provided a historical background and unpublished manuscripts from his private collection of materials concerning SOLOs.

Distinct concepts and terms are associated with SOLOs, and these terms were used as key words to expand the search. A SOLO incorporates topics, goals, rationale, instructional objectives, learning resources/activities, objective-referenced evaluation, pre-tests and formative evaluations called post-tests. These key words were researched individually and information incorporating these key words was located. A broad range of peer reviewed journal articles, books, research reports and dissertations directly related to my topic were reviewed. Various search engines and additional key words were identified with the help of the Mullins Library research librarian. The additional key words identified were: advance organizer, behavioral objective, competency-based education, mastery learning, teaching effectiveness, learner-centered instruction, and outcome- based education. One challenge encountered was that it was

difficult to search key words in education because many words had different meanings and authors used different words to describe the same concept.

This chapter provides an overview of the literature related to Student Oriented Learning Outlines (SOLOs). It is divided into three sections. The first part will provide an overview of the history of SOLOs and the results of previous research utilizing SOLOs; the second part will describe the components of the SOLO; and the third part will review the literature on competency-based education, mastery learning and outcomes based education.

History of SOLOs and Results of Previous Research Utilizing SOLOs

When researching any innovative process or method**,** it is important to gather background information to gain an understanding of the history of the events that led to the development of that particular process of method. As with any innovation, a new method goes through a series of steps, which include starting with curiosity, envisioning what the final method should accomplish, trial and error, and finally improvement. It would be prudent to research the history of a new method thoroughly and would be of enormous benefit to gain firsthand information from the developer of the method. Dr. James Hammons, developer of the SOLO (Student Oriented Learning Outline) was available and could seamlessly review the sequence of events and context of those events, which led him to the development of the SOLO.

SOLO Development

When asked to provide information about the events leading to the development of the SOLO approach Dr. Hammons generously agreed to take the time to reflect back on this, and as he says "tell the story." In Appendix A the series of events which led to the creation of the SOLO is recounted by Dr. Hammons.

Dissertations and Other Works

Much of the research concerning the effectiveness of SOLOs was done in the 1980s, with four research studies and five identified dissertations covering the two decades from 1980 through 2000. A review of the identified dissertations and unpublished and published works pertaining to SOLOs is presented in this section.

Dissertations

A review of the five identified dissertations is presented below in chronological order, and includes purpose of the study, study participants, research design and results.

Covington Baskin Porter, Jr. (1980). Porter's 1980 study sought to examine and identify the effectiveness of Student Oriented Learning Outlines (SOLOs) in four sections of a community college introductory sociology course. Porter utilized a post-test only Control Group Design. The only difference in the randomly assigned groups was the use of SOLOs by the experimental group. The students who used the SOLOs scored significantly higher ($p < .05$) on four of the five tests given during the semester and also had a significantly more positive attitude toward the course ($p < .10$) than the control group.

Porter reported "these [positive] results can be accomplished without deleting any part of the more traditional instruction and without adding anything except the SOLOs" (Porter, 1980, p. 64). Porter concluded "the Student Oriented Learning Outline system is an efficient teaching technique that results in higher student achievement and improved student attitudes" (Porter, 1980, p. 64).

John Edward Preas (1982). Preas utilized Popham's interrupted time series design to determine if the use of SOLOs positively affected student achievement in a community college introductory speech communication course, and if students had a positive attitude concerning

SOLOs. Participants in this study were 82 students who were enrolled in four sections of an introduction to speech communication during the 1980-1981 academic year.

Preas revealed a limitation to his study that influenced his results. He told both the experimental and control groups about the benefits of SOLOs, and as a result, the experimental group shared the SOLOs with the control group, which contaminated the results.

Preas found that, although students expressed a favorable attitude toward SOLOs, this did not always translate into increased achievement. He stated "Students found SOLOs beneficial, especially in organizing their study" (Preas, 1982, p. 85).

Jane Louise Robinson (1983). Robinson's quantitative study was designed to evaluate the use of SOLOs in a community college freshman English composition course, and to determine if the use of SOLOs increased student engagement, interest in and positive attitudes toward the course as compared to traditional instruction. Participants for this study consisted of five sections of freshman composition II. Three sections were in the control group while two sections were in the experimental group. A total of 95 students participated in this study. A post-test only control group design was used. The control and experimental groups were taught in exactly the same fashion, with only one difference; the SOLO was used in the experimental sections.

Robinson found that SOLOs did not influence student achievement, but student attitudes toward utilizing the SOLOs were positive. The most revealing finding was that the use of SOLOs had a positive impact on the performance of weaker students. The experimental group also had fewer late and incomplete assignments and had a more positive attitude toward the course and the SOLOs.

Doris A. Van Horn (1989). The purpose of Van Horn's study was to "determine the impact and effectiveness of SOLOs in a community college business education course as compared with

traditional instruction in a community college business education course" (Van Horn, 1989, p. 8). Students in two sections of a Business Communication class at Westark Community College (now UA Fort Smith) in Ft. Smith Arkansas were the participants. Students were randomly assigned to either the experimental group (23 students) or the control group (25 students). Instruction was the same in both groups, with the exception that the experimental group was provided access to the SOLOs one week prior to the lecture presentation in which the SOLOs were to be utilized. A modified version of Popham's Interrupted Time Series Design was used.

Although the use of SOLOs was not proven statistically significant with respect to student achievement based on test scores, Van Horn suggested that "the use of SOLOs may have indirectly affected the experimental group's study habits" (Van Horn, 1989, p. 112). Based on student comments on the SOLO evaluation, Van Horn reported that the use of Student Oriented Learning Outlines decreased student test anxiety.

Steve Mannings Hyndman (1995). Hyndman used a single case reversal design for his study of 107 participants who were in the Mathies Noncommissioned Officer Academy. Hyndman's 1994 study sought to determine if student achievement, based on test scores, improved when utilizing SOLOs, and if there was a relationship between test scores and students' reading grade level and student attitudes concerning the value of SOLOs.

The results of Hyndman's study revealed that there was no statistical significant difference in achievement based on exam scores for students when they used SOLOs. He also found no statistically significant correlation between test scores and students' reading grade level. Based on the responses that he obtained from the anonymous survey administered to participants, Hyndman concluded "it seems clear that students did have a positive opinion concerning the value of SOLOs" (Hyndman, 1995, p. 133).

Other Works

As pointed out in the introduction to this section, there is a body of published and non-published articles concerning SOLO development and use. Additionally, information about the effectiveness of SOLOs has been presented at regional and national conferences. In this section, these works will be presented.

Unpublished Works. A body of quasi-experimental unpublished works was obtained from J. O. Hammons. While some of these works were complete, others lacked critical pieces of information.

In a 1973 unpublished study, Hammons performed a cross section sample survey on college-wide use of SOLOs at Sumter County Community College. Students (N = 243) were asked to respond to seven questions concerning the use of SOLOs. When students were asked which parts of the SOLO was useful, 88% indicated clear statements of objectives and 90% responded specification of learning activities and resources. Hammons reported that 90% of students responded that using SOLOs reduced anxiety, made learning more efficient, and helped organize both student and instructor. Eighty-eight percent of students reported that SOLOs were helpful, and 78.6% reported that the particular SOLO used was clear and comprehensive (J. O. Hammons, HIED 6323 lecture, October, 2009).

Another unpublished study recounted by Hammons (J. O. Hammons, HIED 6323 lecture, October, 2009) was done at The Pennsylvania State University, in which students in a Master's level business course for non-business majors were surveyed. Although the number of participants was not reported, the results of this study clearly supported the use of SOLOs. When students were asked if they used SOLOs when studying for the unit test, 96.8% reported yes; when asked if they felt the SOLO was helpful, 100% reported yes; when asked if SOLOs

should be provided for each unit, 93.5% reported yes, and 97.8% reported that the self-quiz associated with the SOLO was helpful (J. O. Hammons, HIED 6323 lecture, October, 2009).

As reported by Hammons (J. O. Hammons, HIED 6323 lecture, October, 2009), in 1977 Wallace performed an unpublished study concerning the use of SOLOs in an English composition class at a Harrisburg Area Community College. Students were surveyed concerning the use of SOLOs. The number of students surveyed was not reported. When students were asked if they liked SOLOs, 71% responded positively. At the start of the semester, only 33% of students reported that they enjoyed English courses, and at the end of the semester, 74% of the students reported that they enjoyed English courses (J. O. Hammons, HIED 6323 lecture, October, 2009).

In 1978, Hammons and Hendrix conducted an unpublished study concerning the use of SOLOs in a management course at Pennsylvania State University (J. O. Hammons, HIED 6323 lecture, October, 2009). Although the number of students who participated in the study was not reported, 100% of surveyed students found SOLOs useful, 97% of students wanted SOLOs for other units, 97% found the objectives helpful, 98% found the self-quiz helpful and 85% of students expected to do well on tests (J. O. Hammons, HIED 6323 lecture, October, 2009).

Jane Wei created, utilized and collected data on the use of a SOLO for a Principles of Teaching course in Taipei Municipal College in Taiwan. It is unclear when this study was done, but it was presented in the form of an unpublished manuscript. Ninety-five students participated in her study who ranged from sophomore to graduate level. Students were given a SOLO one week prior to the beginning of lectures on a specific unit. Wei stated that she taught the unit exactly as the course was previously taught, with the exception of including the unit SOLO. A 10-item questionnaire to determine the usefulness of the SOLO was administered to the class

after completing the unit. Wei found that, of the 90 students who completed the survey, 100% found the SOLO useful, 97% found the objectives in the SOLO helpful in studying for the unit exam and also indicated that the objectives helped them to know what was expected of them. Eighty-five percent of the students reported that they expected to do well on the exam. Additionally, Wei determined that 85 of the 90 students who completed the survey indicated that similar materials would be helpful if provided for each unit, and 88 of the 90 indicated that the self-quiz was helpful (Wei, nd).

In addition to these unpublished works, a number of research articles and conference proceedings have been published. These are described below.

Published Works. In 1996 a poster entitled *Using a "Student-oriented learning outline"(SOLO) to improve performance in writing in agricultural science disciplines* was presented at the 56th annual meeting of the ASHS Southern Region by Garcia and Rom, professors at the University of Arkansas. This poster outlined the steps necessary in creating a SOLO unit (Garcia & Rom, 1996).

In 1998, VanArsdale and Hammons described the history, components and use of the SOLO in an article in the *Journal of Continuing Education in Nursing* and presented findings based on using two SOLOs in a health assessment course at The University of Arkansas for Medical Sciences in Little Rock, Arkansas. The two SOLO units developed and studied were "Assessment of the Respiratory System" and "Assessment of the Cardiovascular System." A total of 50 students utilized the SOLOs; 100% reported that they found the SOLOs useful; 96% reported that materials similar to the presented SOLOs would be useful if provided for other units (VanArsdale & Hammons, 1998). The authors also reported that 100% of the participants found the self-quizzes helpful. The researchers provided several open-ended questions, and

found that the most frequently mentioned suggestion "was one advocating use of the SOLO for each body system covered in the health assessment course" (VanArsdale & Hammons, 1998, p. 28). The authors further reported "the mean score on the portion of the examination based on the SOLO was 92% and was the highest mean score in any examination given in the course" (VanArsdale & Hammons, 1998, p. 28).

Emery and Kalscheur (2000) sought to determine if the SOLO could be used to facilitate student learning in a research course at Eastern Kentucky University. They published an article in *The American Journal of Occupational Therapy* entitled "Use of the student-oriented learning outline in research education." Emery and Kalscheur (2000) developed and implemented a SOLO, which was used for four semesters. A total of 88 undergraduate occupational therapy students enrolled in Research Methods courses (n = 29; n = 19; n = 21; n = 19) utilized these SOLOs. The researchers tested research knowledge of participants before and after each course and additionally collected student opinions about the usefulness of SOLOs. A Wilcoxon signed rank test revealed a significant difference in student performance before and after instruction. No comparative data was collected to determine utilizing SOLOs affected student performance. At the end of the course, students were asked to rate a series of statements on a Likert scale (1 = strongly agree; 5 = strongly disagree). Mean scores of evaluative student statements concerning SOLOs (N = 88) as reported by Emery and Kalscheur (2000, p. 338) are included in Table 1. Emery and Kalscheur (2000) reported that the use of the SOLO not only helped to promote student learning, but that the students perceived utilizing SOLOs as helpful. The authors concluded, "Although this use of SOLO was limited to one institution, experience suggests that over four semesters, the SOLO was effective in helping to structure the research course to facilitate student learning" (Emery & Kalscheur, 2000, p. 338).

Table 1

Student Opinions About the Use of SOLOs on a 1 – 5 Likert Scale (1 = strongly agree; 5 = strongly disagree).

Evaluative Statement	Mean
The expectations in the course were clear	4.6
The SOLO handouts increased student learning	4.6
The grading in the course was fair	4.7
The research course was beneficial	4.6
The instructor treated me like an adult learner	4.8
Responses to student questions were provided in class	4.6
Clinical and real-life examples increased understanding	4.6
Opportunities for small group interaction were provided	4.7
Student input was used in the course	4.4

Note. *N* = 88; From "Use of the Student-Oriented Learning Outline in Research Education," by L. J. Emery and J. A. Kalscheur, 2000, *The American Journal of Occupational Therapy*, *54*(3), p. 338.

In 1993, Winters made a presentation about a study using SOLOs at the 11th annual conference of the Association of Baccalaureate Social Work Program Directors. Winters created SOLOs for a course in statistics for undergraduates in social work and sociology. In his study, he compared answers from students on a one to five Likert scale (1 = never; 5 = always) gathered over a two year period. In year one SOLOs were not used and in year two SOLOs were used. There were other changes in this class pertaining to computer availability by students making it difficult to definitively compare one year to the next. Winters pointed out that when the SOLO was utilized, students gave more favorable course ratings in multiple areas including

communication (a half-point increase in student ratings) and appropriateness of tests (nearly a quarter-point increase). In short, “Students rated the SOLOs as very helpful in their learning” (Winters, 1993, p.33). Winters (1993) also indicated that SOLOs had reduced student anxiety and apprehension.

In the next section an overview of the necessary components of a SOLO and how the pieces fit together will be reported. Additionally, the advantages and disadvantages of utilizing SOLOs from the perspective of students and faculty members will be explored.

Components of SOLOs

A Student Oriented Learning Outline is a written document for a specified unit of instruction that is given to students. It contains learning objectives describing what the students will be able to do when they have successfully completed the learning experience, and often includes a pretest which serves one or more purposes: (a) it lets students know how much they already know, (b) it lets students know if they have the requisite skills to successfully complete the unit, and (c) it allows the instructor to identify the level of present skills and knowledge of each student. Creating a SOLO requires the instructor to identify effective and efficient ways students can learn each objective.

In most units a SOLO may also contain a post-test designed to assess student mastery of each objective. In developing a SOLO, faculty usually begins with a topic. For each topic faculty develop one or more learning goals, and then they develop measurable specific learning objectives based on these goals. In short, a SOLO tells students what they are to learn, how they can learn it, and whether or not they have learned it (J. O. Hammons, personal communication, February 1, 2014). An in depth explanation of what makes up a SOLO, a sample SOLO and the advantages and disadvantages of the SOLO will follow.

A well crafted SOLO is a flexible approach in which various instructional methods can be incorporated. Instructors are only limited by their institution's protocol and their own imagination. Objectives for the unit of instruction, suggested learning activities for students to achieve the stated objectives, and a self-quiz to determine if students have learned the material are typically included in the SOLO infrastructure (Emery & Kalscheur, 2000). Individual instructional objectives are paired with learning resources and activities that the learner completes to master each learning objective. Resources can include readings, assignments, activities, video clips, webinars or even directions to take a self-quiz (Emery & Kalscheur, 2000). It is in this phase that the instructor lets the student know exactly what needs to be done to achieve mastery of the unit. If needed, special instructions may be included which align specific learning resources with each objective. A special instruction provides specification of a unique condition. For example, special instructions can be included to let students know if they should skim or read the required text in depth; if they are required to bring specific information or completed assignments to class; if they will work in groups to achieve a goal; or even if there will be a formative quiz over the objective. One of the SOLOs used in this study is provided in Appendix B. In Appendix B it can be seen that the topic is matched with corresponding goals, instructional objectives, learning resources and special instructions. The rationale identifies and communicates to students the importance of learning the information and places the unit in the context of previous units and/or future goals.

The first time a SOLO is presented to students, it is important to explain how it is intended to be used and to answer questions or concerns that students may have. Giving students' information about how various components of the SOLO are intended to help them learn can

increase student buy-in and help students understand the purposes of the various SOLO components and the role these components play in helping them to learn. (See Table 2)

Table 2

SOLO Components from the Perspective of the Student

SOLO Component	Student Perspective
Topics	What the unit is about
Goals	In general, what the student will learn from this unit
Rationale	Why the student should learn the material in the unit
Instructional Objectives	Specifically, what the student will be able to do after learning the unit
Pre-Assessment	Determination if the student is ready to learn and how much of the material the student already knows
Learning Resources and Activities	Where the student should go to get the information they need; what they should do to successfully complete the objective
Special Instructions	The unique conditions or special directions needed to complete the task.
Self-Quiz	How much the student learns, and if the student is ready to go to the next unit
Revision Information (can be included when appropriate)	Student feedback concerning how the unit can be improved and if the use of the SOLO was worthwhile

Note. From "Design and Evaluation," by J. O. Hammons, 2011a, p. 148. Adapted with permission of the author.

Use of SOLOs is intended to be beneficial for students and faculty members alike. SOLOs are also intended to promote independent learning (Emery & Kalscheur 2000). Feedback from faculty members who have used SOLOs describe SOLOs as useful (Hammons & Jaggard, 1984). Appendix C provides a list of the advantages and Appendix D provides a list of the

disadvantages of using the SOLO as reported by faculty and students (Hammons, 2011a). It is apparent when reviewing Appendices C and D that the advantages of utilizing SOLOs outweigh the disadvantages of utilizing SOLOs for faculty members and students alike. The major disadvantage of SOLOs--the amount of time that it takes faculty members to create SOLOs--is outweighed by the benefits to faculty and students.

A properly developed SOLO contains certain components. A discussion of the components of the SOLO follows, including rationale (advance organizer), pre-tests, instructional goals, learning objectives, objective-referenced evaluation and affective objectives.

Rationale (advance organizer)

Rationale, sometimes called an advance organizer, is a framework given to students prior to the start of a unit. The rationale statement serves the following purposes: it identifies and communicates to students the importance of learning the information; it helps students see the value of the unit; and it places the unit in the context of previous units and/or future goals. A well crafted rationale statement should be interesting, simple, and a 'sales pitch' for the unit (Hammons, 2011a, p.154).

Traced to its inception, the term advanced organizer can be credited to Ausubel (1960). Ausubel stated "learning and retention of unfamiliar but meaningful verbal material could be facilitated by advance introduction of relevant subsuming concepts" (Ausubel, 1960, p. 271). In a 1980 meta analysis (N = 135), Luiten, Ames and Ackerson examined published and unpublished studies concerning the effect of advance organizers on learning and retention and concluded "the average advance organizer study shows a small but facilitative effect on learning and retention" (Luiten, et al., 1980, p. 217). Moreover, their findings determined "that advance organizers facilitate learning in all content areas examined, albeit broadly defined, and with

individuals of all grade an ability levels" (Luiten, et al., 1980, p. 217). Stone (1983) analyzed 112 advance organizer studies utilizing a meta-analysis technique. Her results showed that the use of advance organizers were associated with increased learning and retention.

The positive findings of Luiten, et al., (1980) and Stone (1983) are not reflected in other studies. McEneany (1990) suggested that there was reason to doubt that advanced organizers promote learning, and Clark and Bean (1982) concluded that the efficacy of advance organizers yielded little empirical support for their use.

When looking at advance organizers or a rationale statement as it relates to SOLOs, it is important to view the rationale as a structured method of introducing the learning material. Effective instructional design is the root of effective academic instruction (Becker, 2001; MacSuga-Gage, Simonsen, & Briere, 2012), and a clear rationale communicates the importance of the material to be presented, putting it in the proper context for the student. Student's respond positively to a well organized course (Halawah, 2011). An advance organizer is a summary at the beginning of a unit that allows the learner to profit from a more detailed presentation to follow (Van Horn, 1989).

Viewed through a wider lens, SOLOs themselves can be considered an advance organizer for students, and will allow students to see the value of what is to be taught as well as relate the content to previous and past units. A correctly written rationale (advance organizer) in the context of a SOLO should provide a concise, acceptable, believable answer to the question "why is it important to learn this material?" (Hammons, 2011a, p. 156), relate the material to past and future material and provide a clear overview of the material to be studied (Hammons, 2011a).

Sometimes the best way to illustrate a rationale to students for learning material is through the use of a pre-test. Students who do poorly on a pre-test see that they do not know the material, and this can motivate them.

Pre-tests

There is more than one reason that pre-tests are a valuable form of assessment. Students are pre-assessed to determine if they have the requisite skills and knowledge to successfully complete the coursework, to determine if there are any deficits in their knowledge or skills sets, and to determine if they have already mastered any or all of the stated learning objectives (J. O. Hammons, HIED 6323 lecture, October, 2009). A well crafted pre-test is based on the knowledge and skills outlined in the objectives of the course or unit and will let students know if they are ready for the course or unit and how much of the material they have already mastered.

By determining early in the coursework if there are any deficits in knowledge or skills, the student can be directed to resources that will allow the student to fill these deficits. Giving students the opportunity to be properly prepared for new material will help them succeed. Pre-tests are particularly useful early in a course if an instructor suspects that students are not prepared for the coursework that follows.

By pre-testing for a specific unit weeks in advance, students can be directed to learning materials that will help them to be prepared for that unit. For example, if an instructor is going to present a unit teaching students how to administer antibiotics to a horse, it is necessary for students to know how to calculate dosage of antibiotics based on body weight. Students would need to know how to determine the weight of the horse, how to convert kilograms to pounds, how to calculate the dose in milligrams, how to divide the dose by the frequency and how to convert a dose in milligrams to a dose in milliliters. If students do not have a clear

understanding of how to determine the weight of a horse, how to utilize conversion tables and how to work with fractions, they are doomed to fail the unit on administering antibiotics to a horse. In this instance, utilizing a pre-test would allow the instructor to assess the student's knowledge; as necessary, the instructor could provide students with a review of concepts they need to succeed in the learning unit.

Pre-tests can also provide a baseline of student knowledge and skills. Pre-tests that incorporate specific learning objectives serve to clarify the material that the instructor deems important and how the different elements in the course link together (Combs, Gibson, Hays, Saly, & Wendt, 2008). By measuring an objective-based pre-test against an objective-based post-test, the amount of learning that took place in the course or unit can be inferred (Hammons, 2011b).

Instructional Goals

As earlier stated, an instructional goal is defined as a broad, general statement of intended outcomes in skills, knowledge, or attitudes (Hammons, 2011a, p. 43). Goals are usually stated so generally that two or more instructors might not select the same materials or design the same learning activities to achieve them, and they might disagree on the assessment measures for evaluating the results of instruction (Hammons, 2011a).

Providing a statement of unit goals will give students an overview of what they are to learn, and will serve to show students what the instructor deems as important. Instructional goals are written as statements of general outcomes.

Perhaps the best way to illustrate what instructional goals encompass is to compare and contrast them to learning objectives. Learning objectives and goals have one thing in common: they both specify an intended outcome. Unlike goals, properly written learning objectives are

stated in terms of measurable outcomes. Where needed, they may include conditions present when performing the outcome, like time constraints and materials available. They may, where necessary, include criteria by which the performance will be judged. Learning objectives are often used to describe the tangible steps that need to be taken in order for a goal to be achieved.

Typical words used when writing goals are: understand, know, learn, recognize and develop. An example of a goal statement and its companion learning objectives follows:

> Goal - The student will gain an understanding of determining parturition in the mare.
>
> Objective 1 – Given a 5 ml sample of mammary secretion from a pre-partum mare, compute the likelihood that the mare will foal within 48 hours utilizing a titration test.
>
> Objective 2 – Given three pre-partum mares to assess, determine which one is most likely to foal first based on their physical characteristics including.
>
> Objective 3 – Given a mare's age, previous foaling history, and last breeding date, evaluate the likelihood that the mare will foal within a two-week period.

Learning Objectives

As defined earlier, a learning objective is a written statement that communicates what the student should be able to do when they have successfully completed a learning experience (Hammons, 2011a). Learning objectives are stated in terms of measurable, observable and demonstrable actions. Where appropriate, learning objectives may include conditions under which students should perform the desired outcome (time boundaries, materials available, etc.), and include the criteria for judging student performance (Hammons, 2011a, p. 43). Simply put, a learning objective communicates *what* the learner will be able to do, and, if appropriate, the conditions under which the learner to be able to do it and *how well* it must be done.

"Course learning objectives define a course in terms of the outcomes the instructor expects students to achieve" (Combs, et al., 2008, p. 88). It is recommended that course objectives be stated in specific behavioral statements that the instructors wish the students to obtain (Combs et al., 2008; Hammons, 2011a; McKeachie, 2002). Some authors are not prescriptive in how to write successful learning objectives, and some are rigorous and prescriptive.

Hammons suggests that learning objective statements contain the following: an action verb, a product of the outcome of the desired behavior, circumstances or conditions, where necessary, under which the behavior must be demonstrated and standards of proficiency that the behavior must meet (Hammons, 2011a). Examples of a circumstance or condition would be letting students know the conditions under which they will be tested and if a 'pass' means having 100% correct answers on an applied test covering giving injections, or having to complete a task within a certain amount of time.

Although Hammons (2011a) advocates three possible components, Kibler, Cegala, Watson, Barker and Miles (1981) suggest five components of a successful learning objective: (a) who is to perform the desired behavior (b) the specific, observable act (or behavior) that the student is to perform (c) the result or product of the student's behavior (d) the relevant conditions under which the behavior is to be performed, and (e) the standard or criterion that will be used to evaluate the success of the product or performance (Kibler et al., 1981p. 61-69).

Ordering or categorizing objectives is the first step in writing clear learning objectives. A taxonomy, or classification system, can be broadly construed as a system of describing the way that things are put into groups. Utilizing taxonomy facilitates communication. The idea of classifying objectives can be traced back to the 1948 Convention of the American Psychological Association. Benjamin Bloom's interest was sparked during this meeting, and with a group of

experts and educators, he took on the task of classifying objectives (Forehand, 2010). As a result, in 1956, a handbook outlining Bloom's Taxonomy of cognitive domains was created. Since that time, Bloom's Taxonomy has been updated, and in 2001 a revised Bloom's Taxonomy was published. One of the major changes in this revised edition of Bloom's Taxonomy was to change the six major category descriptors from nouns to action verbs (Forehand, 2010). The updated Bloom's Taxonomy model is a grid of cognitive process dimensions and knowledge dimensions, which is helpful in writing learning objectives (Forehand, 2010). The grid in Table 3, created by Anderson and Krathwohl, 2001, depicts the structure of the revised taxonomy and addresses two dimensions of learning (Krathwohl, 2002). The table is structured in the form of a matrix suggesting that the cognitive and knowledge dimensions interact with each other, and the intersections of the knowledge dimension and the cognitive dimension form cells. Objectives can be classified in these cells (Krathwohl, 2002).

Table 3

Updated Bloom's Taxonomy Model and the Relationship between the Cognitive Process and the Knowledge Dimensions

The Knowledge Dimension	The Cognitive Process Dimension					
	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge						
Conceptual Knowledge						
Procedural Knowledge						
Meta-cognitive Knowledge						

Note. From "A Taxonomy for Learning, Teaching, and Assessing," by W. A. Lorin and D. R. Krathwohl, 2001, p. 28.

Action verbs, such as analyze, list, summarize, compose and tabulate are commonly used in writing learning objectives. It is important to use action verbs that produce measurable results, and not to use verbs or phrases that cannot be measured, such as 'knows,' 'learns,' 'has an appreciation for' or 'memorizes'.

Objectives-referenced Evaluation

Objectives-referenced evaluation is an approach to assessing student learning in which tests and other evaluation instruments are based on course objectives (adaptation from Van Horn, 1989). According to Linnenbrink and Pintrich (2003) instructors can enhance students' ability to achieve goals by providing accurate, specific feedback. Objective referenced formative and summative evaluations are often components of SOLOs.

Formative evaluation serves two purposes; it provides feedback to students so they know how they are doing and it provides feedback to instructors so they can identify trouble spots and change teaching methods to improve student learning. This cyclic nature is what defines formative evaluation (Sadler, 1998). The role that formative evaluation plays in student learning is suggested in theory and research (Herman, Osmundson, Ayala, Schneider, & Timms, 2006). Through formative assessment, student needs and student progress are monitored. Herman, et al. (2006) contends that through the use of formative assessment "learning sequences can be appropriately designed, instruction adjusted during the course of learning, and programs refined to be more effective in promoting student learning goals" (p. 1). In a landmark study, Black and Wiliam (1998) documented the benefits of formative assessment. Black and Wiliam's (1998) meta-analysis of 250 studies linking assessment and learning found that "typical effect sizes of the formative assessment experiments were between 0.4 and 0.7" (Black & Wiliam, 1998, p.2). These authors additionally stated "these effect sizes are larger than most of those found for

educational intervention" (Black & Wiliam, 1998, p.2). In short, the value of formative evaluation is undisputed.

Summative evaluation is evaluation used for grading purposes at the end of a unit for determining the extent to which students have mastered the stated objectives (Hammons, 2011a, p. 195). A post-unit test, midterm or final exam are the most commonly used approaches for summative evaluation. As Johnson and Jenkins state, "When objectives are clearly specified and connected to instruction, summative assessment provides information about a student's achievement of specific learning objectives" (Johnson & Jenkins, 2009, para. 4).

Affective Objectives

An affective objective or indicator is a voluntary student behavior which demonstrates that students not only have gained knowledge and skill but also are continuing to voluntarily use the knowledge or demonstrate the skill because they believe it to be worthwhile. Affective indicators are usually collected unobtrusively and anonymously, and will determine if students will do or use what they have been taught (J. O. Hammons, HIED 6323 lecture, October, 2009).

We can trace the importance of affective indicators in the literature to Bloom (1956) and then to Mager (1968) and Krathwohl (1964). Bloom identified three domains of learning: cognitive, psychomotor and affective. The affective domain is concerned with the beliefs, attitudes and values of the student. Krathwohl, Bloom and Masia (1973) developed a hierarchy of five levels of the affective domain: receiving phenomena, responding to phenomena, valuing phenomena, and organization and internalizing values. Progression from the first level to the fifth level corresponds to an increasing level of internalization of attitudes, interest and/or values (Lynch, Russell, Evans, & Sutterer, 2009).

The affective domain is more focused on how a student feels than how they think, and is concerned with what students will do instead of what they know they should do (J. O. Hammons, HIED 6323 lecture, October, 2009). Progressing from the first to the second level of internalization, students start with a willingness to give their attention to an instructor or to the subject matter and receive a form of emotional satisfaction. When students reach the third level, they will attach some value to the subject matter. This value can range from mild acceptance to a real commitment. Upon reaching the fourth level, students organize their values. When students have reached the fifth level, they will integrate their beliefs, attitudes and values into a philosophy that will guide their future behaviors (J. O. Hammons, HIED 6323 lecture, October, 2009).

Achievement of affective indicators is evaluated anonymously and unobtrusively. Indicators of affective change would include approach/avoidance behaviors, unobtrusive behavioral indicators, and direct questioning (J. O. Hammons, HIED 6323 lecture, October, 2009). Approach behaviors would be exhibited by a student who takes additional courses concerning a subject, brings in a news article concerning the subject, or stays after class. A student who delays taking a course or is the first student to leave at the end of class would be exhibiting an avoidance behavior. Examples of unobtrusive indicators are well-prepared students, very well written papers and good questions in and out of class. Generally, faculty members avoid collecting information on affective objectives, because they are unable to specify if they have been achieved, and don't know how to measure achievement of affective objectives. As Hammons says "You don't do what you don't know how to do." (Hammons, 2011b).

Competency-based Education, Mastery Learning, and Outcomes-based Education

Education is comprised of curriculum, or content which is what should be learned and instruction, which describes all the methods used to teach the content (Hammons, 2011a, p.2). Former Secretary of Education Arne Duncan and President Barack Obama have both spoken in favor of competency-based programs, and support giving students' credit for what they know instead of credit for "seat time" (Carney, 2013; Chan, 2014).

Competency-based Education

As faculty, our job is not to sort students, but to prepare students for their futures by providing assistance and helping them to learn. Competency is defined in Webster's Dictionary as "the quality of being adequately or well qualified physically and intellectually" (Morse, 2014). When used in the context of education,

> Competency is a statement of a minimum standard of knowledge or skill that learners are expected to acquire stated in sufficient clarity that it is possible to determine whether or not a student does or does not possess it (J. O. Hammons, HIED 6323 lecture, September, 2009).

Competency-based education (CBE) is not a new concept. In the 1950s, Bloom developed a taxonomy for educational objectives. Shortly thereafter, the concept of CBE emerged and can be traced back to the 1960s in response to concerns that students were not taught the skills that they needed for specific jobs or for life after school (Malan, 2000). Defining CBE is made more difficult because educators use different terms to describe the same thing. For example, competency-based education, individualized instruction, learning for mastery, and programmed instruction are often used interchangeably (Blank, 1982).

While different authors gave a slightly different ways of describing CBE, they all include a number of principles (Hammons, 2011a; Malan, 2009; Oglesby, 2013; Van Der Horst, & McDonald, 1997)

1. Students are assessed prior to instruction to determine where within the curriculum they should start the learning process.
2. Course competencies are determined by the knowledge, skills and attitudes deemed important for graduates.
3. Course competencies are given to students prior to instruction. Course competencies may include all levels of skills or knowledge.
4. Instructional activities are selected because they are effective and efficient ways for students to master competencies.
5. Assessment criteria are developed and matched to matched competencies or objectives, and are based on predetermined standards. Performance-based evaluation is criterion-referenced and is based on required outcomes.
6. Students advance (are awarded a certificate, etc.) when they have demonstrated mastery.

In addition to the design principles, there are implied characteristics of CBE (Hammons, 2011a; Oglesby, 2013)

1. CBE is individualized.
2. Revision is based on student feedback.
3. A systematic instructional design is implemented.
4. Instruction is organized into units or modules of manageable size.
5. The student as well as the instructor is held accountable for student achievement.

6. Instructional strategies are chosen based on their efficiency and effectiveness in helping students to achieve stated competencies.
7. The selected content is based on desired competencies.
8. The responsibility for student learning is shared between student and instructor.
9. The role of the teacher is fundamentally changed. Teachers guide students to produce evidence of mastery. They focus on student learning and not student grades.
10. More feedback is given to students in the form of rapid differentiated support. Formative assessments are aligned with learning objectives, and these assessments allow students to focus on trouble spots that are blocking their achievement of mastery. Summative assessments are adaptive and timely. Teachers assess competencies in multiple ways.
11. Assessments are tied to previously stated learning objectives.
12. Greater emphasis is placed on gathering evaluation data; revisions are based on these data.

The proponents of CBE point out the value of this system to learners. As Table 4 shows, there are fundamental differences between CBE and a conventional approach to education.

Table 4

Comparison of Conventional Education and Competency-Based Education

	Conventional	Competency-Based
Method of Instruction	Lecture, Discussion, Laboratory	Varies with objectives – May be a large group, independent study, laboratory, etc.
Learning Objectives	Generally not defined; vague	Clear and specific
Successful Learning	Often not clear about what constitutes successful learning; norm-referenced	Successful learning defined by predetermined standards; criterion referenced
Teachers	Focused on teaching	Focused on student learning
	Lead class discussion, dispense knowledge	Guide students to produce evidence of mastery
Assessment	Summative assessment relied upon heavily; mid-term and final	Includes summative assessment
		Uses frequent formative assessment as feedback to guide student learning
		Formative assessment used to improve instruction
		All assessment matched to competencies/objectives

Note. Adapted from "Design and Evaluation," by J. O. Hammons, 2011a, with permission of the author.

Mastery Learning

Mastery learning is a system of instruction based on the assumption that most students can learn at high levels previously thought obtainable by only a small percentage of students. A course based on mastery learning principles is oriented toward desired terminal performances and instruction focuses on the individual student. The instructor's primary role is that of a learning manager. A student's performance is evaluated by comparing it with an absolute standard, and grading is based on achievement of objectives, not on the comparison of one student to another (Hammons, 2011a). In short, mastery learning is a philosophy that asserts that under certain conditions virtually all students can master most of what they are taught, and instructors can teach so that students do learn (J. O. Hammons, HIED 6323 lecture, September, 2009).

The idea of mastery learning can be traced back to Benjamin Bloom. Bloom (1968) believed that teaching systems should be provided that would enable a majority of students to master subject matter and methods and materials should be developed that would enable the largest proportion of students to master material taught. When outlining the important components of the mastery concept, Bloom (1968) made five assumptions:

1. Bloom (1968) stated that the aptitudes of students in a class resemble a bell curve: at one end of the curve were students who were particularly gifted, and at the other end of the curve were students with special disabilities for a particular type of learning, such as difficulties a tone deaf student would experience when studying music, or a color blind student would experience when studying art. Bloom thought that the vast majority of students were in the middle of the

aptitude bell curve, and that most students could master material if the proper instructional system was used.

2. Bloom (1968) felt that different students needed different types and qualities of instruction to achieve mastery of subject matter. Some students needed concrete illustrations, more examples, or multiple repetitions of the same type of problem to achieve mastery.
3. Bloom (1968) suggested that a student's ability to understand instruction, whether the teacher's instructions to a class or the instructional materials used, would affect mastery. Tutors, study groups, alternate text books and workbooks were suggested as effective alternative measures that could positively affect student mastery of subject matter. Bloom (1968) believed that teachers should utilize instructional alternatives that would enable a majority of students to learn subject matter at a high level.
4. Bloom (1968) determined that perseverance level of the student had an effect on mastery of subject matter. Bloom (1968) believed that ascertaining the correct learning materials for individual students would enhance the likelihood that they would spend time on task.
5. Bloom (1968) also believed that time spent on learning could be reduced if learning time could be used more effectively.

There are many strategies to achieve mastery of learning according to Bloom (1968). Bloom thought that providing tutors, self-pacing of instruction and providing different tracks within a school system would benefit a student's achievement of mastery. Bloom, 1968, recommended the use of formative assessments. He also believed that if non-mastery areas were pointed out to

students, along with specific suggestions for improvement, then most students would do what was needed to achieve mastery (Bloom, 1968).

Support for mastery learning is found in the literature. A review of almost 40 meta-analyses revealed that mastery programs have produced positive effects in achievement outcomes (Kulik, Kulik, & Bangert-Drowns, 1990).

Outcomes-based Education

Outcomes-based education (OBE) cannot be traced back to a single source. Some say it traces back to B. F. Skinner; others say it traces back to mastery learning proposed by Benjamin Bloom; and others say the concept of OBE is derived from the curriculum objectives of Ralph Tyler (Jansen, 1998). William Spady is generally regarded as the leading proponent of OBE (Malan, 2000). Spady (1994) defines outcomes-based education in the following way:

> Outcome-based education means clearly focusing and organizing everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences. This means starting with a clear picture of what is important for students to be able to do, then organizing curriculum, instruction, and assessment to make sure this learning ultimately happens (Spady, 1994, p. 12).

Spady (1994) lists two factors necessary for an outcome-based system: (a) creating a clear set of learning outcomes and (b) establishing the opportunities and conditions that enable students to achieve those outcomes (Spady, 1994, p. 12). When discussing OBE it is important to clearly define the term outcome. Spady (1994) stated "outcomes are clear learning results that we want students to demonstrate at the end of significant learning experiences" (Spady, 1994, p. 13). These outcomes are not beliefs, opinions or attitudes but instead are an application of what the student has learned. Outcomes involve actual performance, and need to be defined according to

the desired action. Observable action verbs such as explain and produce should be used when developing outcomes. "Without those verbs, what are called outcome statements lack a clearly defined demonstration process, and without that defined process the outcome statement takes on the character of a goal rather than a true outcome demonstration" (Spady, 1994, p. 13).

The roots of outcomes-based education can be traced back to mastery learning and competency-based education (Malan, 2000). As seen in Table 5, OBE, mastery learning and CBE have many similarities.

Table 5

Like Characteristics of Three Educational Approaches

Characteristics	Outcomes-based	Mastery Learning	Competency-based
Outcomes define system	X	X	X
Allows for expanding learning opportunities beyond traditional seat time as learning time	X	X	X
Based on successful attainment of predetermined performance outcomes	X	X	X
Aided by instructional guidance where learners receive continuous learning support	X	X	X
Builds on a culminating achievement of desired learning outcomes	X	X	X
Geared towards integrating concepts across the curriculum and learning areas	X	---	---
Success-oriented allowing for individual learners to succeed according to own abilities	X	X	---
Characterized by cooperative learning	X	---	---
Attainment of outcomes is confirmed by criterion assessment	X	---	X
Based on collaborative structures allowing for democratic input from the community	X	---	---

Note. From "The 'new paradigm' of outcomes-based education in perspective," by S. Malan, 2000, Information in table gleaned from Malan, 2000, *Journal of Family Ecology and Consumer Sciences, 2*, p. 2

Two of the OBE characteristics are not seen in CBE or mastery learning. In OBE, mastering content is not an end in itself, and implementation of OBE decreases individual competition and encourages teamwork (Malan, 2000). Malan further describes OBE curriculum as not fixed and "open to the environment" (Malan, 2000, p. 27).

Chapter Summary

Chapter II provided an overview of the literature related to Student Oriented Learning Outlines (SOLOs). An overview of the history of the SOLO, literature supporting the use of the SOLO, and the components of the SOLO were presented. The components of the SOLO - rationale, pre-tests, instructional goals, learning objectives, objectives-referenced evaluation and affective objectives were discussed. In addition, an explanation of competency-based education, mastery learning and outcomes-based education was discussed.

III. METHODOLOGY

Introduction

The purpose of this quantitative study was to determine if there was a positive relationship between the use of SOLOs and three measures: mastery of material taught, retention of material taught, and voluntary student behaviors related to course material. This chapter will explain the rationale for selecting the research design, the selection of participants, and the procedures and tools used in collecting data.

The following research questions guided the study. For University of Arkansas students enrolled in an equine production course:

1. After controlling for student high school grade point average, was there a significant difference in student performance on each of three exams between students taught using SOLOs and students taught using traditional methods?
2. To what degree do students taught using SOLOs retain the material covered, as measured on unit exams?
3. Are SOLOs rated by students as useful to them in preparing for exams or in helping them to determine what they were expected to learn?
4. For each unit taught using SOLOs, voluntary affective indicators of behavior were collected. Is there evidence of voluntary positive student behaviors related to the goals of the SOLO unit?

Selection of the Research Design

An Analysis of Covariance (ANCOVA) was selected for this study for research question one. This design consisted of treatment and control groups that were a convenience sample not randomly assigned. In the present case, the covariate was high school grade point average.

Research questions two, three and four were based on a single group design, where the intent was to provide only descriptive information. Research question two concerned the retention of material taught with the use of SOLOs. Unit exams covered both SOLO and non-SOLO material. Scores on the SOLO and non-SOLO portions of the unit exams were compared. Research question three concerned student perceptions of the usefulness of SOLOs, and research question four concerned quantifying evidence of voluntary student behaviors related to the goals of the SOLO unit.

Development and Approval of Instruments

Before this research was conducted, I developed and pilot-tested SOLOs and exam questions. Exam questions were reviewed by Dr. N. Jack, a professor of Equine Science, and SOLOs were reviewed by Dr. J. Hammons, professor of Higher Education, author of the SOLO and expert in the field of SOLO development. An expert is defined as an individual possessing special skills or knowledge in a given area (Gove, 1981). Research was reviewed and approved by the University of Arkansas Institutional Review Board (Appendix E). A consent form that explained the research and that refusal of participation would not affect the relationship with the instructor or effect benefits was given to the students (Appendix F). Students were allowed to ask questions about the research, and then were given the opportunity to sign the consent form or opt out of the research. An additional request was made and approved by the IRB (Appendix E) to utilize the aptitude, demographic and in-class performance data from 2012 students of the same course.

Variables

The treatment variable for this study was the use of SOLOs as a teaching methodology for specific units in a horse production course. The dependent variables were retention of SOLO

material as measured by the unit exams. Additionally, assessments of the usefulness of SOLOS to students and affective indicators relating to SOLOs were collected.

Treatment Variable

Faculty members should seek ways to increase learning efficiency of students (Hu & Kuh, 2003) and can increase student learning by making every minute that students are in class or studying count (Groccia & Miller,2000; Hu & Kuh 2003). The purposes of this quantitative study were to determine if the use of SOLOs had a positive influence in three areas: mastery of material taught, retention of material taught and voluntary student behaviors related to the use of course material.

I designed three SOLOs that were distributed to students who were in the treatment group. SOLO materials included subject matter pertaining to course objectives, pre-tests, post-tests and SOLO evaluations. The control group was taught identical subject matter without the use of SOLOs. Unit exams were developed and administered at designated time-points throughout a 15-week semester to the treatment and control groups.

Dependent Variables

The dependent variables in this study consisted of three assessments: knowledge of subject matter, usefulness of SOLOs, and affective behaviors exhibited by students utilizing SOLOs. The dependent variables were assessed in the following ways: unit exams were used to assess of knowledge of subject matter for the control and the treatment group; anonymous rating sheets were used by students in the treatment group to assess the usefulness of SOLOs; and I unobtrusively collected affective indicators exhibited by the treatment group after utilizing SOLOs.

Knowledge of Subject Matter. The following subject areas were assessed in the unit exams for both the control and the treatment groups: (a) foal IgG, (b) colostrum, and (c) emergency horse care. The knowledge of subject matter was assessed by unit exams. Unit exams at the end of each of three course units included material taught to the control and treatment groups. For the treatment group, one SOLO taught lab was included on the unit exam. The same material was taught to the control group but without the use of SOLOs. The material covered on the unit exams for both groups was foal IgG, colostrum or emergency horse care. The questions were not exactly the same, but they covered the same objectives.

Usefulness of SOLOs. Students in the treatment group were asked to rate the value of the SOLOs at the end of the SOLO unit (Appendix G). A series of between nine and eleven statements was developed to determine the usefulness that students placed on the three SOLO units. These statements were rated on a 1 – 5 Likert scale. Responses were collected anonymously. Sample statements students were asked to rate included were "This module made it easy for me to understand exactly what I was expected to learn" and "I think that being taught this way would be beneficial to me in other courses." Additionally, open-ended questions were provided requesting information about what students liked most and least about SOLOs.

Affective Indicators. An affective indicator is a voluntary student behavior, which demonstrates that students not only have gained knowledge and skill but are continuing to voluntarily use the knowledge or demonstrate the skill because they believe it to be worthwhile, and are not influenced by a reward or grade compensation. Atherton (2004) reported that affective indicators provide information about the participant's feelings or emotions. Affective indicators of the treatment group were collected unobtrusively by the researcher after each of the

three SOLO units: (a) foal IgG, (b) colostrum, and (c) emergency horse care. The affective indicators collected for the treatment group were:

- Colostrum: When the SOLO materials were made available, an e-mail was sent to the students in the class. This e-mail included links to journal articles along with a message that said that no questions on exams or the final would come from the material found in the articles. Students were asked to anonymously answer the true/false statement "I read the journal articles provided, although they weren't required".
- IgG: When the SOLO materials were made available, a reminder e-mail was sent to the students in the class. Included in this e-mail were links to journal articles with a message that no questions on exams or the final would come from the material found in the articles. The number of students who anonymously indicated that they read these articles was tabulated. Additionally, the number of students who opted to stay after lab to ask questions and discuss what was included in the journal articles was recorded.
- Emergency horse care: This lab was planned to end 15 minutes prior to the end of the scheduled lab time. At the end of the emergency horse care lab, I made an announcement that any student who wished to practice hands-on skill sets learned in lab could take the opportunity to practice utilizing equipment and supplies. I also told the class that I would be available to answer any additional questions pertaining to the lab. The number of students who stayed after the lab ended was recorded, as well as the number of students who remained after the scheduled end of lab. Additionally, students requested additional opportunities to practice what they had learned in lab. This number of students was recorded.

Research Site and Participants

The sample for this study consisted of sophomore, junior and senior-level University of Arkansas students pursuing a minor in equine science who were enrolled in an equine production class in either the spring of 2012 or the spring of 2013. This non-probability sample was used because of the accessibility of participants (Ary, Jacobs & Razaviech, 2002). Thirty-one students enrolled in the 2012 class were in the control group and 27 students enrolled in the 2013 class were in the treatment group. Both semester-long 15-week classes consisted of a weekly lab lasting 1 hour and 50 minutes and 2 weekly lecture classes lasting 50 minutes each. The research site was the equine production lab located in Whitaker Animal Science Center at the University of Arkansas.

Data Collection

The sequence of events including the topics taught and exam schedule for this study is provided in Table 6. The only difference between the treatment and control group course experiences was the use of SOLOs. The sequence and topics were the same for both groups.

Three labs utilizing SOLOs were taught. Other labs were taught without the use of SOLOs. All 50 minute lecture classes were taught without SOLOs.

For the SOLO presentations, pre-tests and post-tests were utilized. Pre-tests were administered in advance of the SOLOs. An anonymous student evaluation form pertaining to the SOLO unit was given to the students at the completion of the SOLO lab. These evaluation forms asked students to evaluate the usefulness of the SOLO on a 1 – 5 Likert scale (1 = strongly disagree; 5 = strongly agree), and also included open-ended questions asking students to describe what they liked best and least about the SOLO unit. Affective indicators of student engagement were observed and collected for each lab where SOLOs were used. As outlined in Table 6,

SOLOs covering the indicated topics were given to the students. SOLO taught topics were: colostrum, foal IgG, and emergency horse care.

Table 6

Semester-long Timeline for Equine Production Class Showing Sequence of Activities

Week	No. subjects	Content of SOLO Lab	Affective Indicators Collected	Content of non-SOLO Lab	Content of non-SOLO classes	Unit Exam	Final
1				Syllabus Review	Anatomy		
2					Conformation		
3				Monitoring Parturition	Unsoundness		
4	27	Colostrum	X		Mare Reproduction		
5					Broodmare Mgt.	Exam 1	
6	17	Foal IgG	X		Pregnancy Hormones		
7				Practical Nutrition	Stallion Repro		
8				Field Trip	Equine Diseases		
9					Equine Genetics	Exam 2	
10				SPRING BREAK			
11	21		X	Emergency Care	Controlling Parasites		
12				Parasitology	Internal Parasites		
13					Equine disorders	Exam 3	
14				Pasture Management	Nutrition		
15					Fencing and Housing		
16							Final

Material covered in each of the three unit exams utilized in this study included information from: one SOLO lab and all non-SOLO lectures and labs. Exams including SOLO-taught material were administered on the fourth, sixth and eleventh week of the semester.

Data Analysis

Each participant's high school grade point average was collected. This information was obtained from a data request to the registrar's office and delivered securely through the Associate Director for Assessment in University Housing using the University secure file transfer system, also known as "Dropbox IT." All identifiers for the treatment and control groups were subsequently removed, and a random identifying number was added for each participant. I entered data into an excel spread sheet, and all data were carefully cleaned and reviewed for missing data.

Descriptive statistics and an ANCOVA was conducted for each of the three unit exams to analyze research question one to determine if there were significant differences in the outcomes of each unit exam. The ANCOVA technique removed the portion of each participant's exam score that was in common with their high school grade point average, allowing an estimate of the distinct effect of the treatment on each outcome, independent of prior academic achievement. Before calculating the ANCOVA could be done, there were eight primary assumptions that needed to be tested and met (Appendix H). These eight were: equal sample sizes, absence of outliers, normality of sampling distributions, homogeneity of variance, linearity, homogeneity of regression, correlation of covariate and dependent variables, and reliable covariates. The alpha level that was used to determine the statistical significance of each ANCOVA test was .02. Effect sizes were adjusted for the covariate.

Descriptive statistics were used to analyze research questions two and three. Means, frequencies and percentages were calculated for question three concerning the usefulness of the three SOLOs utilized by the treatment group.

Descriptive statistics or "techniques for organizing, summarizing, and describing observations" (Ary, Jacobs & Razaviech, 2002) were used to analyze research question four, which collected evidence of voluntary student behaviors related to the goals of the SOLO unit.

Threats to Validity

Students in the treatment and control groups were given three unit exams that tested objectives of the same material. The control group was taught material *without* the use of SOLOs in 2012, and the treatment group was taught the same material utilizing SOLOs in 2013. According to Creswell (2008), threats to internal and external validity need to be addressed in experimental research in order to make valid inferences. Problems that threaten the ability to draw correct cause-and-effect inferences because of experiences of participants or the experimental procedures utilized cause threats to internal validity (Creswell, 2008). There are eight potential threats that could have affected the internal validity of this study (Creswell, 2008, p. 312).

The first threat to internal validity was history. Students in both the control group and the treatment group were allowed a variable amount of time between when the material was presented and the unit exams. Because of the nature of this study, and the fact that students required time to study, the researcher could not control or monitor events that took place in the interim. Results of this study could have been affected by the length of time that individual students spent studying material, and any other environmental event or external influence.

Changes that could occur due to maturation, and simply the passage of time, were the second threat. Participants could have become wiser, less motivated or even more motivated due to scores they received on previous exams, and it is reasonable to conclude that this may have affected the results (Ary, Jacobs & Razaviech, 2002; Cresswell, 2008).

The third threat to internal validity, regression, was negligible. Regression was controlled for because this was a convenience sample of intact groups, and thus participants for this study were not selected for either low or high performance on any critical variables, and were matched to the best of the ability of the researcher.

Differential selection, the fourth threat to internal validity, was present. Differential selection "is most likely to occur when the researcher cannot assign subjects randomly but must use intact groups" (Ary, Jacobs & Razaviech, 2002, p. 285). In an attempt to minimize the threat of differential selection, effects of high school grade point average were statistically controlled.

The fifth threat to internal validity was mortality. If participants dropped out of the study for any reason, this would create the threat of mortality (Creswell, 2008). Two students chose not to participate in the control group. Because the control and treatment groups were matched, validity issues due to mortality were negligible.

The sixth threat to internal validity concerned interactions with selection. Some threats may have interacted in such a way to affect internal validity. For example, one of the groups could have had a higher rate of maturation, and the selection-maturation interaction could have been mistaken for the effect of the treatment. One group may have had more pre-vet students. These students would have been more motivated to earn the high grades necessary to be competitive for vet school. While this is a threat to internal validity, it is not highly likely that it could be an alternative explanation for the results observed. Each year there is a mixture of students in this

particular course, so it is safe to conclude that the classroom composition was very similar for the treatment and control groups.

The two remaining potential threats to internal validity were testing and procedures. Pre-tests and post-tests were administered as part of the SOLO units. This was a threat to internal validity because the treatment group may have benefited from the use of these tests. For the unit exams, a different set of questions was developed for the treatment group and control group. Both groups were tested over unit objectives, but the wording of the questions was not identical.

It is impossible to generalize the results of this study due to threats to external validity not under the control of the researcher. Threats to external validity are defined by Creswall (2008) as "problems that threaten our ability to draw correct inferences from the sample data to other persons, settings, and past and future situations" (Creswell, 2008, p. 310).

Chapter Summary

This chapter described the methodology for this study. Included in this chapter were the instruments, research design, data collection information and techniques utilized in the data analysis. The participants of this study consisted of two intact classes of 4000 level undergraduates who were enrolled in an equine production class within the Department of Animal Science at the University of Arkansas in 2012 and 2013. Descriptive statistics and *t*-tests were used to evaluate the difference in knowledge that students obtained when utilizing SOLOs and not utilizing SOLOs. Additionally, affective indicators were collected unobtrusively and student rating of SOLOs was collected.

IV. RESULTS

Introduction

This chapter begins with an overview of the study including information about participants and data analysis. Four types of data were collected and analyzed for this study: Analysis of covariance for results of three different exams for SOLO and non-SOLO taught students, descriptive statistics for retained SOLO taught material for three SOLOs, descriptive statistics for anonymous student perceptions concerning three SOLOs and descriptive statistics of voluntarily affective student behavior for three SOLOs. Data analysis is followed by a presentation of the data obtained and the process of analyzing the data. A summary of the results and major findings concludes this chapter.

Overview of the Study

The study sample consisted of a control group of 28 students enrolled in a horse production class in 2012 and a treatment group of 25 students enrolled in a horse production class in 2013 at the University of Arkansas who consented to participate in this study. Both were 15-week classes, which consisted of a weekly lab lasting 1 hour and 50 minutes and 2 weekly lecture classes lasting 50 minutes each. The research site was the equine production lab located in the Whitaker Animal Science Center at the University of Arkansas.

Both the treatment and control groups were taught the same material; the only difference was that the treatment group was given a SOLO one week in advance of three labs. All other labs and lectures were taught without the use of SOLOs. Additionally, the treatment group was given a pre-test, a post-test, and an anonymous student evaluation form pertaining to the SOLO unit at the completion of the SOLO lab. Additionally, affective indicators of student engagement were

observed and collected for each lab where SOLOs were used. Table 7 depicts the statistical analyses utilized for this study.

Table 7

Statistical Analyses Utilized for Research Questions

RQ#	Construct	Statistical Analysis
RQ1	Comparison of SOLO and non-SOLO groups	ANCOVA
RQ2	Retention of SOLO material	Descriptive statistics: *M, Mdn*, %
RQ3	Student Perceptions of SOLOs	Descriptive statistics: *M*, %, *f*
RQ 4	Affective Indicators	Descriptive statistics: *M*, %, *f*

Presentation of the Data

Lab exam scores on three units taught with and without SOLOs were compared utilizing Analysis of Covariance (ANCOVA). ANCOVA is a "statistical technique used to control for the effect of an extraneous variable known to be correlated with the dependent variable" (Ary, Jacobs, & Razaviech, 2002, p. 292). ANCOVA is primarily concerned with reducing error variance and increasing statistical power when there are two intact groups. Because of concerns that students' high school grade point averages could be related to the dependent variables (unit exam scores), grade point averages were correlated with performance on unit exam scores and ANCOVA was used to control for any effects due to differences in grade point averages.

Descriptive statistics were also used to analyze the data. The analysis of these results were examined independently for each research question and summarized.

Results

Comparison of SOLO and non-SOLO Groups

IgG, Colostrum, and Emergency Horse Care Unit Exams. An Analysis of Covariance (ANCOVA) was conducted for each of the three unit exams. Before this could take place, however, there were eight assumptions that needed to be tested and met before ANCOVA could be conducted. These eight were: equal sample sizes, absence of outliers, normality of sampling distributions, homogeneity of variance, linearity, homogeneity of regression, correlation of covariate(s) with the dependent variable, and reliable covariates. Effect sizes and proofs of assumptions are in Appendix F. A conservative alpha level of 0.02 was used to determine the statistical significance of the ANCOVA tests for the three unit exams because multiple statistical tests were made.

The non-SOLO group had a higher grade point average and a higher percentage of seniors, which may have given the non-SOLO group a slight advantage in exam performance. Despite this fact, on two of the three unit exams, colostrum and emergency horse care, the SOLO group outperformed the non-SOLO group. The observed differences between the two groups were statistically significant. For the IgG unit exam, the non-SOLO group outperformed the SOLO group. However, this difference was not statistically significant. (Table 8)

Table 8

ANCOVA Tests of IgG, Colostrum, and Emergency Care Unit Exams, Non-SOLO vs. SOLO

Variable	*LS Means*	*df*	*Type III SS*	*F*	*p*	R-squared
IgG		1	29.54	4.34	0.04	0.08
Non-SOLO	11.56					
SOLO	10.01					
Colostrum		1	36.63	6.53	0.01	0.12
Non-SOLO	11.20					
SOLO	12.00					
Emergency Care		1	103.30	18.62	<0.001	0.28
Non-SOLO	10.92					
SOLO	13.85					

Retention of SOLO Material

The retention of SOLO taught material as measured by exam scores is depicted in Table 9. Twenty-five students in the 2013 horse production class took all three of the unit lab exams, which were worth a total of 25 points each, and covered SOLO taught material. On the first lab exam, testing retention of the colostrum SOLO unit, the average score was 87%. On the second lab exam, testing retention of the IgG SOLO unit, the average score was 73%, and on the third exam, testing retention of the emergency horse care SOLO unit, the average was 89%.

Table 9

Means, Medians and Percentages of Correct Answers (out of 25 total points) on Unit Exams Covering Information Presented in Three SOLO Labs; Colostrum, IgG and Emergency Horse Care

SOLO Lab	*N*	*M*	Mdn.	% Correct
Colostrum	25	21.68	18.14	87%
IgG	25	24.0	19.0	73%
Emergency Care	25	22.14	22.5	89%

Unit exams were comprised of material taught in SOLO labs and non-SOLO material taught in additional labs and lectures. Table 10 depicts the percentage of correct answers for SOLO and non-SOLO material covered on the three unit exams. In every case, the students outperformed on the questions covered in the SOLO taught material versus the questions covered in the non-SOLO taught material. Exam 1 included the information from the colostrum SOLO; exam 2 covered the information from the IgG SOLO; and exam 3 covered the information from the emergency horse care SOLO.

Table 10

Percentages of Correct Answers on Unit Exams for SOLO and non-SOLO Material

Unit Exam	*N*	*% Correct non-SOLO*	% Correct SOLO
Exam 1	25	81%	87%
Exam 2	25	68%	73%
Exam 3	25	78%	89%

Student Perceptions of the Use of SOLOs

Overall Use of SOLOs. Students in the 2013 horse production class were asked to anonymously rate statements pertaining to SOLOs. At the end of each of the three SOLO labs, seven statements were rated on a 1 – 5 Likert scale (1 = strongly disagree; 5 = strongly agree). In Table 11, the overall ratings based on the Likert scale are presented. The range in means for all statements regardless of SOLO unit was between 3.44 and 4.62. The averages of the means for all of the statements pertaining to the three SOLO units were: colostrum SOLO $M = 3.85$, IgG SOLO $M = 4.31$, and emergency horse care SOLO $M = 4.27$. The colostrum SOLO was the first taught. After students had the opportunity to participate in a SOLO-taught lab, the mean overall statement scores of the remaining two SOLO rose, indicating that as a group the students agreed with the statements.

Table 11

Average Student Ratings by Statement Regardless of SOLO and Average Student Ratings for Statements Concerning SOLOS Utilized in Three Labs: Colostrum, IgG, Emergency Horse Care

	Overall Rating			
	Colostrum	IgG	Em Care	Total
Statement	*n* = 25	*n* = 17	*n* = 21	*N=63*
SOLOs made it easy for me to prepare for exams	3.88	4.35	4.00	4.05
SOLOs would be helpful in other courses	3.92	4.30	3.71	3.95
SOLOs helpful in determining what I am expected to learn	3.92	4.06	4.10	4.02
I found the activities and scenarios helpful	3.72	3.94	4.76	4.13
The self-quiz was beneficial	4.04	4.53	4.62	4.37
Handouts were pertinent	4.04	4.47	4.24	4.22
I liked the SOLO	3.44	4.53	4.48	4.08
7 statement average based on SOLO Unit	3.85	4.31	4.27	4.11

Note. Ratings on 1 – 5 Likert Scale (1 = strongly disagree; 5 = strongly agree)

Value of SOLO when Preparing for Exams. Student ratings of statements concerning SOLOs can be seen in Table 12. When students were asked to rate the statement "SOLOs make it easy for me to prepare for exams," 52% of students strongly agreed with this statement for the colostrum SOLO unit, 52.4% of students strongly agreed with this statement for the emergency horse care SOLO unit, and over 70% either agreed or strongly agreed with this statement for the IgG SOLO unit. Fewer than 10% of the students felt that the SOLO was not helpful in preparing for exams. In examining the total average score for all three SOLO units, 67% of students who

responded to the evaluations either strongly agreed or agreed that SOLOs were beneficial when preparing for exams.

Table 12

Frequency and Percentages of Student Ratings for Three SOLO Unit Evaluations of the Statement "SOLOs make it Easy for me to Prepare for Exams"

		Strongly Disagree		Dis-agree		Neutral		Agree		Strongly Agree	
Unit	*N*	*n*	%	*n*	%	*n*	%	*n*	%	*N*	%
Colostrum	25	2	8%	2	8%	5	20%	3	12%	13	**52%**
IgG	17	0	0%	0	0%	5	29.4%	6	**35.3%**	6	**35.3%**
Em Care	21	1	4.8%	1	4.8%	4	19.1%	4	19.1%	11	**52.4%**
Total	64	3	4.7	3	4.7%	14	23.4%	13	20.3%	30	**46.9%**

Note. Bold indicates greatest percentage of student answers per unit;
1 – 5 Likert Scale (1 = strongly disagree; 5 = strongly agree

Value of SOLO when Determining what to Learn. The majority of students who completed the anonymous SOLO evaluations strongly agreed with the statement "The SOLO is helpful in determining what I am expected to learn" (see table 13). Of the students who responded, 68% either agreed or strongly agreed concerning the colostrum SOLO, 72.2% either agreed or strongly agreed concerning the IgG SOLO and 59.1% either agreed or strongly agreed concerning the emergency horse care SOLO. The analysis of the total average score for all three SOLO units showed that over 67% of the students either agreed or strongly agreed that the SOLO was helpful in determining what they should learn, while less than 10% of the students felt that SOLOs were not helpful in determining what they should learn.

Table 13

Frequency and Percentages of Student Ratings for Three SOLO Unit Evaluations of the Statement "The SOLO is Helpful in Determining What I am Expected to Learn"

		Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
Unit	*N*	*n*	%	*n*	%	*n*	%	*n*	%	*N*	%
Colostrum	25	3	12%	1	0.4%	4	16%	5	20%	12	**48%**
IgG	17	0	0%	0	0%	5	27.8%	6	33.3%	7	**38.9%**
Em Care	21	1	4.6%	1	4.6%	7	31.8%	5	22.7%	8	**36.4%**
Total	64	4	6.25%	2	3.16%	16	25%	16	25%	27	**42.19%**

Note. Bold indicates greatest percentage of student answers per unit;
1 – 5 Likert Scale (1 = strongly disagree; 5 = strongly agree)

Student Perceptions of SOLOs: Open-Ended Questions, Colostrum SOLO. In addition to the student ratings, students were asked to anonymously respond to two open ended questions at the completion of the three SOLO labs; these questions concerned what students liked most and least about the SOLO labs. Table 14 reports frequency of both positive and negative responses concerning the colostrum SOLO taught lab ($N = 25$). Twenty-four students identified components of the colostrum SOLO they liked most, while only nine identified things they liked least about the colostrum SOLO.

Table 14

Frequency of Anonymous Student Responses for Pros and Cons of Colostrum Solo Unit (*N* = 25).

Student Responses			
Pros	Frequency	Cons	Frequency
Straight forward	1	Some concepts difficult, but class cleared up questions	1
Solidifies facts	1	One question from pre-test wasn't in reading material	2
Easy for me to learn what I should learn	2	More work for me before class	2
Good way for me to learn because of detail provided	2	Had a hard time getting on blackboard to retrieve SOLO	4
More interaction with material	2		
Hands-on activities/ real life scenarios	3		
Pre-test: so you know what you don't know	6		
I can learn at my own pace, then ask questions in class for clarification	7		

Student Perceptions of SOLOs: Open-Ended Questions, IgG SOLO. Eighteen students anonymously responded to two open-ended questions which asked about the pros and cons of the IgG SOLO at the end of the IgG SOLO lab. A majority of students reported they liked the learning activities and hands-on portion associated with this SOLO, while almost a half of the students reported that the IgG SOLO covered a lot of material.

Table 15

Frequency of Anonymous Student Responses for Pros and Cons of IgG Solo Unit (*N* = 18).

Student Responses			
Pros	Frequency	Cons	Frequency
Pre-test helped me focus on what I didn't know	2	Length of SOLO material	2
Hands on	2	No time to prepare for class, so I felt behind	4
Easy for me to know what I should learn	3	Covered a lot of material	5
Activities/Scenarios/Hand-on portion	8		

Student Perceptions of SOLOs: Open-Ended Questions, Emergency Horse Care SOLO. At the end of the horse emergency care SOLO lab, students were asked two open-ended questions pertaining to the pros and cons of the horse emergency care SOLO. Responses and frequency of responses are reported in Table 16. Seventeen students reported advantages for the SOLO, while only nine reported disadvantages for the SOLO. Nine students reported they liked the activities and scenarios included in the emergency care SOLO, and four students indicated that they found the information concerning emergency horse care applicable to real life situations with horses.

Table 16

Frequency of Anonymous Student Responses for Pros and Cons of Emergency Horse Care Solo Unit (*N* = 21).

Student Responses			
Pros	Frequency	Cons	Frequency
Straight forward	2	Covered a lot of material	1
Hands on	2	Don't like hands on	1
Information applicable to real-life situations	4	Didn't review SOLO before class, so was lost	1
Activities/Scenarios	9	Group work	1
		Don't like having to prepare for class	1
		Use color, not b/w pictures for group work	2
		Length of SOLO material	2

Affective Indicators

For each of three labs taught using SOLOs, affective indicators of behavior were collected. The findings from each of the SOLO taught labs: colostrum, IgG and emergency horse care are reported below.

Affective Indicators for Colostrum SOLO Lab. Students were provided links to journal articles via e-mail along with a message indicating that they would not be tested over the provided journal articles. This e-mail was sent out one week in advance of the SOLO taught lab. As part of the SOLO evaluation, students were asked to anonymously answer the true/false

statement: "I read the journal articles provided, although they weren't required." Of the 25 students who completed the evaluation, 10 students, or 40%, responded "true" indicating that they had read the provided journal articles.

Affective Indicators for IgG SOLO Lab. One week in advance of the SOLO taught IgG lab, students were again provided links to journal articles along with an e-mail message stating that they would not be tested over the articles provided. As part of the post-SOLO anonymous student evaluation, students were asked to respond to a true or false statement: "I read the journal articles provided, although they weren't required." Of the 18 students who completed the evaluation, 22% anonymously indicated that they had read the journal articles.

Affective Indicators for the Horse Emergency Care SOLO Lab. To assess student affective behavior, this lab was carefully planned so as to end 15 minutes before the end of the schedule lab time. Then, an announcement was made so that, although the lab was over, students could stay to practice hands-on skill sets learned during the emergency horse care lab if they chose. Of the 21 students who were in the emergency horse care lab, 16 opted to take advantage of the opportunity to practice hands on skills sets. Additionally, 8 students stayed after the scheduled end of lab to continue asking questions and practice newly acquired skill sets. Of all students participating in the horse emergency care SOLO lab, 73% exhibited positive affective indicators.

Chapter Summary

Four types of data were obtained in an effort to determine if utilizing SOLOs: (a) made any difference on unit exam performance for three unit exams: colostrum, IgG and emergency horse care, (b) influenced the retention of material as measured by unit exam scores, (c) were

perceived as useful by students when preparing for exams and determining what they were expected to learn and (d) produced evidence of voluntary affective indicators by students.

On two unit exams, the SOLO group significantly outperformed the non-SOLO group. On the third unit exam, the non-SOLO group outperformed the SOLO group but the difference was not statistically significant.

When students anonymously responded to statements concerning SOLOs, their perceptions were overwhelmingly positive, underscoring the fact that the students found the SOLOs useful in preparing for exams and a useful guide for what should be learned.

Positive affective indicators of student behavior were exhibited in each of the three SOLO labs; this demonstrated that students not only gained knowledge and skill but also continued to voluntarily use the knowledge or demonstrate the skill because they believed it to be worthwhile. Forty percent of the students who participated in the colostum lab, 20% of the students who participated in the IgG lab, and 73% of the students who participated in the emergency horse care lab exhibited positive affective indicators of behavior.

V. FINDINGS, DISCUSSION, CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

Introduction

This chapter will provide an overview of the study, which includes the purpose of the study and participant information. Next, findings will be presented by research question. Finally discussions and conclusions will be reported, followed by limitations, implications for practice, recommendations for future research, and concluding remarks.

Overview of the Study

The purposes of this quantitative study were to determine if the use of SOLOs had a positive influence in three areas: mastery of material taught, retention of material taught and voluntary positive student behaviors. In assessing the use of SOLOs, exam scores of students on three unit exams taught with and without the use of SOLOs were compared. Then, the amount of SOLO taught material retained by students as evidenced by unit exam scores was examined. Next, anonymous student feedback about their perceptions of the usefulness of SOLOs was collected and reported. Finally, voluntary affective indicators of positive behavior were collected.

Participants in this study were University of Arkansas students who were enrolled in an equine production class; 28 enrolled in 2012 and 25 enrolled in 2013. Both classes included a weekly lab and two weekly lectures during a 15-week spring semester, and the course content was exactly the same. Although both classes were taught the same material, three of the 2013 labs included the use of SOLOs.

Four types of data were collected and analyzed for this study. To avoid skewing the results, high school grade point average was held constant through the use of analysis of covariance (ANCOVA). Descriptive statistics for exam scores was reported, anonymous student

perceptions concerning SOLOs were examined and voluntarily affective student behavior for students utilizing SOLOs was described.

Findings

In this section, the four research questions addressed in this study are recounted. Each research question is followed by a brief description of the results.

Research Questions

Research Question One: After controlling for student high school grade point average, was there a significant difference in student performance on each of three exams between students taught using SOLOs and students taught using traditional methods?

Students in the SOLO group outperformed the students in the non-SOLO group on two of the three unit exams, colostrum and emergency horse care. These results were statistically significant at the 0.02 level. For the IgG exam, the non-SOLO group outperformed the SOLO group, but this difference was not statistically significant.

Research Question Two: To what degree do students taught using SOLOs retain the material covered, as measured on unit exams?

Performance scores from three unit exams were collected for 25 students in the 2013 horse production class. These three unit exams tested retention of SOLO and non-SOLO material. Descriptive statistics were calculated and reported for each of the SOLO taught portions of unit exams as means, medians and percentages of correct answers. Percentages of correct answers were reported for the non-SOLO material for each of the unit exams. For unit exam one, students averaged 87% on the SOLO material (colostrum) and 81% on the non-SOLO material; for exam two, students averaged 73% on the SOLO material (IgG) and 68% on the non-SOLO

material; and for exam three, students averaged 89% on the SOLO material (emergency horse care) and 78% on the non-SOLO material.

Research Question Three: Are SOLOs rated by students as useful to them in preparing for exams or in helping them to determine what they were expected to learn?

At the end of each of the three SOLO taught labs, students in the 2013 horse production class were asked to anonymously rate statements pertaining to SOLOs. A 1 – 5 Likert scale was used where 1 = strongly disagree and 5 = strongly agree. Twenty-five students completed the colostrum SOLO evaluation, 18 students completed the IgG SOLO evaluation and 21 students completed the emergency horse care SOLO evaluation. Descriptive statistics were used to analyze how students rated the use of all three SOLOs. For all SOLO taught labs, 46.9% of students rated statements "5" on a 1 – 5 Likert scale, indicating they strongly agreed that SOLOs: made the material easier to learn, made the information easier to study, found the self-quiz a good indicator of their knowledge of the subject matter, reported that the pretest was helpful in learning the material, and thought that SOLOs would be beneficial if used in other courses.

Students were asked to rate the statement "This SOLO made it easy for me to prepare for exams." Fifty-two percent of the students who completed the evaluation strongly agreed with this statement as it pertained to the emergency horse care SOLO and the colostrum SOLO. For the IgG SOLO, 70% of the students either agreed or strongly agreed that the SOLO made it easy for them to prepare for exams.

When asked to rate the statement "The SOLO is helpful in determining what I am expected to learn," 68% of the students either agreed or strongly agreed for the colostrum SOLO, 73% of the students either agreed or strongly agreed for the IgG SOLO, and 59% of the students either agreed or strongly agreed for the emergency care SOLO.

Students were asked to report their likes and dislikes of the three SOLOs. The number of positive responses far outweighed the negative responses. Students reported almost twice as many likes as dislikes (56 to 29). Thirty-nine of the 56 positive student responses associated with SOLOs concerned three areas: value of the hands-on opportunities, value of the pre-test or the value of SOLO in determining what to learn. Two thirds of dislikes reported by the students were not specific to SOLOs, and concerned the amount of material covered, inability to navigate BlackBoard or not having time to prepare for class.

Research Question Four: For each unit taught using SOLOs, voluntary affective indicators of behavior were collected. Was there evidence of voluntary positive student behaviors related to the goals of the SOLO unit?

Affective indicators were collected from each of the three labs taught with SOLOs. The results are listed below.

- Colostrum Lab: Twenty-five students in the treatment group were e-mailed links to journal articles pertaining to colostrum. This e-mail included a message informing them that they would not be tested over the information provided in the journal articles. Of the 25 students who anonymously completed the SOLO evaluation at the end of the colostrum lab, 10 reported that they had read these articles.
- IgG Lab: Students were provided links to journal articles along with an e-mail message stating that they would not be tested over the articles provided. Of the 18 students who completed the evaluation, four indicated that they had read the provided journal articles.
- Horse Emergency Care Lab: Of the 21 students who participated in the emergency horse care lab, 16 opted to practice hands on skills sets, even though it was not required, and

eight of these students stayed after the scheduled end of lab to continue asking questions and practice skill sets.

Discussion

A discussion of the results of these findings with additional information not apparent from data and findings presented earlier follows. Highlighting areas that could have affected these results is necessary to give the reader a complete understanding of the study and a clearer picture of events as they transpired. The discussion will be presented in the order of research questions.

Research Question One

As pointed out above, the results from the first research question revealed that there was a significant increase in exam scores for students in two of the three SOLO taught exams when high school grade point averages were held constant. Although these results were positive, the SOLO taught group had to overcome additional obstacles that the non-SOLO group did not have to overcome. The exams given to the non-SOLO group were predominantly multiple choice (MC) and true false, while the exams given to the SOLO group were predominantly single best answer (SBA) and short answer. Multiple choice questions, while easy to score, allow for guessing and are difficult to effectively construct (Begum, 2012) and in this case, give the student at least a 25% - 33% chance of guessing the correct answer. True/false questions give the student a 50% chance of guessing the correct answer. Random guessing is limited with the single best answer format. The fact that there was no way to simply guess the correct answer on the SOLO exams is another positive indicator of the value of SOLOs.

The difference in the types of questions used to assess knowledge of subject matter between the control and the treatment group could have affected the outcome of this study. The single best answer format is used to test application of knowledge, judgment and problem solving to a

greater extent than other forms of testing (Begum, 2012; Twort & Mucklow, 2011). Additionally, this type of format lets the student demonstrate that they know *how* to do something, rather than just *know* the correct answers (Begum, 2012). Multiple choice and true false questions test the first two categories outlined in Bloom's Taxonomy; remember and understand. Test questions used to test the SOLO taught material were in the single best answer format and were designed to increase the difficulty of the answers required from simply remembering to more complex categories outlined by Bloom, namely analyze, evaluate or create. In most instances, students in the SOLO group were given questions that were designed to test their application skills, while students in the non-SOLO group were given questions that were based on recall. Even though students who were taught with a SOLO had to provide answers to more difficult questions, they significantly outperformed those who were taught without a SOLO on two of three exams. Examples of the difference in question difficulty between the SOLO and non-SOLO exams can be seen below.

After matching questions from the 2012 and 2013 exams, it became apparent that while the matched questions tested knowledge of the same material, the questions given to the SOLO group were more difficult than those given to the non-SOLO group. The level of difficulty of the questions for the SOLO group was greater than for the non-SOLO group. Examples follow:

- *Question 1 - Control group question:* "A foal is born and the mare's colostrum has a specific gravity of 1.08. The foal appears healthy, but has no suckle reflex and is 3 hours old. Which of the following would be the best choice? a) Carefully thaw some colostrum at room temperature and give via naso-gastric tube; b) Harvest colostrum from the mare, and give it to the foal directly to its stomach through a naso-gastric tube; c) Buy pre-tested plasma and give an IV transfusion."

Question 1 - Corresponding treatment group question: "The specific gravity of your mare's colostrum is 1.0. At 2 hours of age, the foal appears healthy and has a great suckle reflex. What course of action would you take?

When looking at these two questions, it is obvious that simply guessing the answer on the first question would give students a 33% chance of obtaining the correct answer. To respond with the correct answer, the corresponding treatment group question would require that students be able to analyze the situation, realize that colostrum with a specific gravity of 1.0 is unacceptable, and also know the best course of action based on the foal's age. in order to respond with the correct answer.

- *Question 2 - Control group question:* T/F "There are tests that measure the IgG concentrations within the bloodstream of the foal. These tests often are not preformed until the foal is at least 12 – 18 hours old, although peak absorption is at 24 hours of age."
  Question 2 - Corresponding treatment group question: "You want to be certain that foals born under your care have sufficient immunoglobulins in their blood. At what age (in hours) is it best to perform a SNAP test?"

Students in the control group who answered the first question had a 50% chance of getting this question correct, even if they guessed. The only piece of information that students in the control group needed to be familiar with was that absorption of immunoglobulins in the foal is complete at 24 hours of age. The second question in this series was a question given to the students in the treatment group. These students would have needed to know: a SNAP test measures immunoglobulins in the bloodstream of the foal; absorption of immunoglobulins is complete at 24 hours of age; and if a SNAP test is performed at 12 – 18 hours of age, a foal can be given high quality colostrum or a transfusion to positively affect the IgG level by 24 hours of

age. Although these two questions cover the same concept, it is certainly more difficult to answer the treatment group question correctly. In addition to simply being able to guess the correct answer 50% of the time, the control group did not need to understand the material in the depth to answer the question correctly; the treatment group did.

The first unit taught utilizing the SOLO was the colostrum unit. The format of the SOLO was different for the students, and questions about how to use the SOLO were fielded by the instructor. Even though students had not yet learned how to navigate a new learning tool (SOLO), the students utilizing the SOLOs outperformed those not utilizing the SOLOs.

Only eighteen of twenty-five students attended the IgG lab. This lack of attendance could have negatively affected the exam scores. Although the results were not significant, students in the non-SOLO group out performed students in the SOLO group based on unit exam scores for the IgG unit. Had more students taken advantage of the IgG lab, the unit exam scores of the students in the SOLO group could have been higher. Lab attendance, and hence time on task, could also have positively affected the results of the SOLO group. Additional reasons that student performance on the IgG SOLO unit exam was low include (a) the students could have simply not been interested in learning about IgG; (b) the students could have gotten a false sense of security after scoring high on the colostrum SOLO unit exam; (c) other class exam schedules could have competed for their study time; or (d) the IgG SOLO taught material was not as clearly presented as the other two SOLO taught units. Examining the student reported negatives for the IgG SOLO unit helped to put these finding into perspective. Students indicated that they did not have time to prepare for the IgG lab and complained that the IgG SOLO covered a lot of material. These statements, coupled with the fact that a markedly lower number of students attended the IgG lab, point to a lack of time spent by students on the IgG unit. After reviewing

these results, the IgG SOLO and the teaching strategy for this SOLO were reworked to ensure the IgG information was easier for students to understand.

Research Question Two

This research question used unit exam scores for the 2013 horse production class to analyze student retention of SOLO taught material. Although the students knew what type of unit exam format to expect, this format was different than the multiple choice or true/false format used in other equine science courses. Despite the fact that the change in exam format could have negatively impacted exam scores for material taught utilizing SOLOs, it did not. Despite the change in exam format for the SOLO material, the students not only retained the material better when taught with SOLOs, they also performed better on the portion of their exams that was in the new format.

Research Question Three

The third research question concerned student perceptions about the usefulness of the SOLO. After attending the corresponding SOLO lab, students were given SOLO evaluation forms to fill out for the three SOLOs.

There were many things that could have affected student responses to these anonymously answered questions. Not every student attended every SOLO taught lab. There were 25 students who attended the colostrum lab, 18 who attended the IgG lab, and 21 who attended the emergency horse care lab. It is important to point out that students reported about half as many negatives as positives for utilizing the SOLOs. The negatives had to do with inability to access Blackboard, lack of time to study, or amount of information covered. Although simply an observation, these negatives are common despite type of instruction utilized. An observation about the positives of SOLOs indicated by students: the majority of the student positive

responses revolved around the scenarios and learning activities that were designed to emphasize application and evaluation skills. Students enjoyed the challenges presented by the opportunity to analyze and apply pieces of knowledge that they had acquired. Additionally, the scenarios contained in them applied information learned in previous SOLOs.

It is important to note that the first SOLO taught was the colostrum SOLO because anonymous student ratings of statements were lower for this SOLO than for the two subsequent SOLOs. Mean averages in all of these instances were: colostrum 3.85, IgG 4.31, and emergency horse care 4.48. Students rated the SOLO after the corresponding lab. Students who rated the SOLO after the colostrum lab had no way of knowing if the SOLO would help prepare them for exams or help them to determine what they were expected to learn. It is not surprising that this fact is reflected in the ratings received on these statements for the first SOLO (colostrum). A mean average of 3.85 indicated that, as a group, the students found the Colostrum SOLO mildly useful when preparing for exams or determining what they were expected to learn. Ratings for the same statements on subsequent SOLO labs were much higher as students either agreed or strongly agreed with the value of the SOLO in preparing for exams and determining what they were expected to learn. In short, after the students gained familiarity with the SOLOs, their perceptions of the value of the SOLO improved dramatically.

Research Question Four

The fourth research question concerned affective indicators of student behavior exhibited when SOLOs were used. The number of students who exhibited positive affective indicators was impressive: 25% for the colostrum lab and 73% for the emergency horse care lab, and 22% for the IgG lab. Students voluntarily read and discussed journal articles, and practiced emergency horse care techniques well after the completion of the scheduled lab period which is indicated

that the knowledge that they gained and skills that they learned were perceived by them as worthwhile.

Conclusions

In the following section, the results presented will be compared to results previously reported concerning the use of SOLOs. Specifically, the results of this study will be compared to other studies that examined SOLOs in the following contexts: increased achievement, student perceptions of the usefulness, and affective voluntary student behaviors. This is followed by a discussion of the elements of the SOLO with emphasis on the value of writing clear objectives and a discussion of the broader conclusions that can be drawn from this study.

Most researchers who sought to find evidence of increased achievement by students utilizing SOLOs have failed to do so (Hydman, 1995; Van Horn, 1989; Robinson, 1983; Preas, 1982). The one exception was Porter (1980) who reported that students scored significantly higher ($p <$ .05) on four of five tests when utilizing SOLOs. Similar to the results reported by Porter, the present study found that, when SOLOs were used, students scored significantly higher on two of three exams.

Responses concerning the usefulness of the SOLO revealed in this study are reflected in all other studies (Emery & Kalscheur, 2000; Preas, 1982; Robinson, 1983; VanArsdale & Hammons, 1998; Van Horn, 1989; Winters, 1993). Students found SOLOs to be useful when preparing for exams, helpful in determining what to learn, and reported that they liked utilizing the SOLOs. Furthermore, they reported that SOLOs would be beneficial to them if available in other classes. The fact that this study, along with all previously published studies reported positive feedback from students about the usefulness of SOLOs is evidence of the value students

see in SOLOs. It is important to note that these studies took place over four decades – and the perception of SOLOs by students has not changed, regardless of changing student characteristics.

Robinson (1983) found that students had a more positive attitude toward a freshman English composition course when SOLOs were utilized. The results presented by Robinson (1983) coupled with the results of the present study support the conclusion that the use of SOLOs positively affects student voluntary behaviors. These behaviors demonstrate that students have not only gained knowledge and skill but continue to voluntarily use the knowledge or demonstrate the skill. Although collecting incidence of affective indicators is not often done, faculty members truly concerned about student use of previously taught material should collect evidence of these behaviors.

As pointed out in Chapter I, stakeholders in higher education have been increasingly demanding improvement in the quality of education (Education Commission of the States, 1995; National Survey of Student Engagement, 2001). Land grant universities such as the University of Arkansas are under enormous legislative and stakeholder pressure to improve retention rates of students, especially in the science fields (McShannon et al., 2006). The faculty members of the University of Arkansas, Department of Animal Science Equine Program share the concerns of stakeholders and are interested in retention and student success. As discussed in Chapters I and II, concerned faculty members should be aware of student success factors: external factors over which they have no control over, characteristics of today's students, and finally the role faculty members can play to positively affect the education that students receive. As Braxton and Mundy (2002) underscored in their article, faculty members should do what they can to positively affect student success. Capitalizing on student abilities and offering students an opportunity to learn in an environment that motivates and engages them should be the goal of all

faculty members. Faculty members should seek ways to increase their ability to assist motivated students learn more efficiently. The SOLO is a learner-centered approach to teaching that has been shown to have a positive influence on student motivation to learn and to help them to facilitate learning (Emery & Kalscheur 2000). Because of this, the SOLO has broad implications for higher education.

As pointed out in Chapter II, the SOLO is built around seven essential components: topics, goals, rationale, instructional objectives, pre-assessment, learning resources, special instructions and a self-quiz. When faculty focus on learning objectives and provide reasons why students should achieve them, students can direct their learning appropriately and faculty can select activities that will best realize the stated objectives. The SOLO allows students to know what is expected of them, the importance of learning material, what to do to achieve mastery of the material, and a means of determining prior to being graded, if they have achieved mastery. The SOLO is a neatly packaged way to address the essential elements of effective teaching and has been proven to positively affect student performance, help students with retention of material and demonstrated that students provided SOLOs exhibit affective indicators that show they find the material that they were studying worthwhile.

A critical element in the development of a SOLO or any other effective teaching strategy is the development of effective learning objectives. A learning objective is a statement that lets the students know what they should be able to do when they have successfully completed a learning experience (Hammons, 2011b). Correctly writing learning objectives is not an easy task, and while most faculty members teach, few have been educated on how to write clear, measurable learning objectives.

Hammons maintains that the ability for faculty to write objectives at different levels of complexity is a necessary prerequisite for maximizing student learning (Hammons, 2011b). Regardless of the subject matter, to achieve mastery, different courses require different levels of performance or ability from students. For example, instructors in an introduction to sociology class may be satisfied if students simply know definitions of often used terms, while instructors of a parasitology class may require students to develop the ability to apply information and techniques learned to evaluate and create a least-cost, effective deworming protocol for cattle. This later type of learning outcome is clearly more demanding than simple knowledge of definitions.

Bloom's Taxonomy is a classification system that includes six types of cognitive abilities that range from merely remembering material to more difficult tasks such as the ability to evaluate or judge information depending on the situation (Schultz, 2005). Using Bloom's Taxonomy in writing objectives allows faculty to (a) identify the abilities they want students to exhibit and (b) ensure their evaluation methods are fair. An instructor, who is familiar with the knowledge about the various levels of cognitive learning objectives and the type of mental processes they describe, can determine the levels of performance required by students, write objectives that incorporate these different levels of ability, and assess students at appropriate levels of difficulty.

Objectives should be written for the student, and should be stated in a way that describes what the student will be able to do at the end of the unit of instruction. Objectives, where possible, should be written as umbrella objectives. An umbrella objective is any objective for which it is possible to write more than one appropriate exam question. With proper training, faculty can write most objectives as umbrella objectives. By writing umbrella objectives, students can be

provided a formative self-quiz that allows them to determine if they have achieved mastery of learning objectives prior to taking a graded examination.

Clear objectives (preferably umbrella objectives) determine teaching strategies and assessment approaches (Hammons, 2011b). Clear objectives also facilitate the design of valid student assessment. By teaching to the objective and not the test, and utilizing formative assessment and feedback, the level of mastery of material by students will increase.

Faculty members concerned about student learning should strive to become better skilled in the craft of teaching. Despite the problems that students have allocating time to study, they performed better when SOLOs were used. When the level of achievement required was raised, students still performed better when SOLOs were utilized. Use of the SOLO is one effective teaching strategy that has been proven to be valuable in achieving the goal that all faculty members should be concerned with: helping students achieve mastery of difficult subject matter.

In the next section, limitations and delimitations of this study will be presented. The limitations are enumerated. Factors encountered that may have affected the results of this study, and the ability to generalize results are revealed.

Limitations

1. The University of Arkansas Institutional Review Board protocol required students who participated in the study to sign an informed consent form. Two students who were enrolled in the class chose not to participate in the study. Their data and exam scores were not used. It is not known if those students who chose not to participate in the study performed better or worse than those students who chose to participate or if their performance would have affected the results.

2. No effort was made to determine if any of the students had prior knowledge of the subject material or had participated in similar classes prior to the beginning of the semester.
3. The principal researcher of this study was also the instructor of all SOLO and non-SOLO one hour and fifty minute lab classes (as well as a limited number of non-SOLO fifty minute lecture classes). Every effort was made to teach SOLO and non-SOLO classes with the same amount of enthusiasm to avoid demonstrating bias.
4. A limitation to this study was the small sample size. Only 28 students were in the control group, and 25 students were in the treatment group. Although every student in both groups completed all of the unit exams, many students did not attend the SOLO taught labs – particularly the IgG lab. In order to generalize results, large numbers of students to increase sample size would be needed.

Delimitations

This study was delimited to University of Arkansas students enrolled in an Equine Production class during the spring of 2013.

Recommendations for Future Research

Recommendations for future research, with a focus on the limitations of this study, are presented in this section. Limitations of this study included sample size, instrument reliability and research design. This study provided evidence of a positive effect of the Student Oriented Learning Outline on student achievement as measured by unit exam scores for two out of three exams. This fact, coupled with the positive input by students on anonymous evaluations and positive results in other studies, warrant additional research with SOLOs. Offered below are suggestions for further research:

1. More follow-up quantitative studies are needed. In order to increase the rigor, decrease the threats to validity and generalize the results of this study, replication with large numbers of students from multiple university equine science programs is needed.
2. The instructor developed instruments utilized in this study, and they should undergo additional testing for increased reliability and validity.
3. The value of the effectiveness of the SOLO as a method utilized in teaching online should be explored.
4. Studies should be conducted to determine if the use of SOLOs reduces student test anxiety.
5. A longitudinal study of the effects of SOLOs versus traditional instruction should be explored to determine long-term retention of material taught.
6. Studies should be conducted to determine if adult learners benefit from the use of SOLOs. Adult learners prefer to receive a rationale for the importance of information they are receiving and a clear path of how this information can be utilized (Fleming & Garner, 2009).
7. Research with SOLOs should be conducted with multiple instructors utilizing the SOLOs to determine if different teaching techniques or instructor character traits influence the success of utilizing the SOLO**.**

It is impossible to generalize these findings to other horse production courses, but the findings presented in this study do support the use of SOLOs as part of the University of Arkansas horse production class.

Recommendations for Improved Practice

In this section, recommendations for practice are presented. These recommendations are based on the review of literature, observations by the researcher, and data collected with from utilizing three SOLOs in an equine science horse production course.

Students are changing. The characteristics of students in college today are different than those in college even two decades ago. The amount of time that college students spend on educational activities has decreased, as has the amount of time they spend working either full or part-time. Students of 2014 have vast quantities of information available at the tips of their fingers, and socialize via Face Book. Students 20 years ago did not have access to these. Students enrolled in college today desire structure and direction to their educational activities. They desire faculty to help them sort out relevant, applicable information, and to provide structure in learning endeavors. Any actions by faculty to maximize the effectiveness and efficiency of students' time on task will help. Faculty members need to understand the characteristics of college students and in doing so can positively influence student success. Utilizing the SOLO is one strategy that faculty members can influence student success.

One way to determine if students deem what they are taught is worthwhile is through unobtrusive observations of voluntary affective behaviors. In the present study, affective indicators of behavior were collected in SOLO labs, showing that students found the material presented in the SOLOs worthwhile. Additionally, students provided positive feedback for the use of SOLOs on anonymous rating sheets. This information provided evidence that students perceived the SOLO and the information taught utilizing the SOLO valuable. The fact that students performed significantly higher on two of three exams when SOLOs were utilized is a good indication that utilizing the SOLO helped with retention of material. This information,

taken as a whole, points to the fact that the SOLO can increase student success. This is the primary goal of concerned faculty. The use of the SOLO should be explored in other areas of study.

In this study, students responded positively to activities that linked subject matter with real-life situations. The inclusion of a *Scenarios Work Sheet,* which allowed students to work individually or in groups to determine a course of action based on the knowledge they gained, may improve the effectiveness of the SOLO, or in the retention of material in general. The effect of including a *Scenarios Work Sheet* on student retention of material in other areas could be studied.

This study may serve as a point of reference for other instructors of courses in higher education on the effectiveness of SOLOs. Concerned faculty need to do something to increase student success, which ultimately leads to student retention. Continuing to do the same thing when our students are changing simply does not work.

Concluding Comments

Students wholeheartedly supported the use of SOLOs, exhibited positive affective indicators after participating in a SOLO taught lab, and anonymously rated the SOLO as very helpful on multiple criteria. SOLOs proved to be very beneficial to both students and the instructor in organizing concepts. The SOLO additionally proved beneficial to students who could not attend lab because of sickness or work obligations.

This study proved that the use of the SOLO significantly increased student achievement on two out of three equine production unit exams. The SOLO has the potential to increase student retention of information taught in equine science as well as other courses of study. Being clear about objectives and providing a roadmap showing students how to master these objectives, are

hallmarks of the SOLO and are a necessity for both students and faculty. An approach to instruction built around the SOLO offers a strategy that would meet the needs of both faculty and students in achieving their common goal of student success.

From a personal standpoint, I found the development of the SOLO to be time consuming, but well worth the effort. Creating a SOLO for individual units of instruction caused me to examine *why* the information I was teaching was important for students to learn, *how* I was going to present the information and *what* learning resources were needed for students to master selected material. Creating umbrella objectives took time, but allowed the students to know what they would need to internalize in order to do well on the exam; umbrella objectives provided a framework for me to easily write relevant exam questions. Self-quizzes were invaluable in helping students focus their efforts on parts of the units they had not mastered. The implementation of the SOLO clearly influenced student mastery of material. Furthermore, while developing the first version of a SOLO is time consuming, time to revise it to use the next time is much less. My quest to become a more effective and efficient instructor has been realized through the use of the Student Oriented Learning Outline (SOLO). Being able to provide students with a clear path to the mastery of more difficult subject matter and having a large percentage of students achieve this mastery has truly reorganized and revitalized my teaching.

VI. REFERENCES

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APPENDIX A

Development of the SOLO Approach

Being able to look at the classroom from both sides of the teacher's desk enabled Dr. Hammons to develop an approach to teaching that serves both teacher and student well. Below is the recounting by Dr. James Hammons of the events that led up to the development of the SOLO:

> I will begin by saying that the development of the SOLO approach was a process, not an event—and one that is still continuing.
>
> I first said the word SOLO during my brief stay at the National Laboratory for Higher Education (1972-73). I was explaining to colleagues why the major focus of the community college division of the Lab—teaching faculty how to write self-instructional modules (while much needed to facilitate continuous entry and exit in developmental math and English courses, and to help students master certain learning objectives), would never be workable for other courses. Instead, I argued, what is needed—and would work, is something that told students what they were to learn and how to learn it—a student-oriented learning outline—a SOLO! I remember sketching out what I had in mind.
>
> A year later, I left the National Lab and joined the Penn State Center for The Study of Higher Education. I've always believed I was selected to join the Center because of my background in academic administration, my teaching experience, my work with faculty development while at the National Lab—and my enthusiastic "yes" when asked if I would like to develop a course on college teaching. I was told they had been looking for the right person for two years.

I had several months to prepare before I taught it the first time. During that time I contacted everyone I could find who was teaching a college teaching course—which wasn't difficult because there were so few of them. I also purchased the handful of available books about college teaching. To tell it like it was, "I wasn't impressed." In general, the syllabi and the books were "about college teaching"—not "how" to do it. So, as I began sketching out ideas about content, I found myself thinking back to two of my undergraduate experiences, approaches I had experienced as a student officer in the military, my experiences as the Educational Officer in a Nike Missile Battery, several experiences in my master's program at Southern Illinois University, a couple of significant experiences in my doctoral program at the University of Texas, and several major learning experiences as Dean of the College at Burlington County College. As I think back, these experiences and what I learned from them really influenced my thinking as I developed that first syllabus.

As I began thinking about the new course on college teaching, four events during my undergraduate days really influenced my thinking. Two of these pertained to the most important challenges of any teacher—grading and preventing cheating. As a result of them, I undertook a major review of the literature on grading practices and cheating and decided to include a unit on grading and another unit on ways to avoid cheating in my new course.

The first event happened in a general education course in psychology. Going into the final, I had "set the curve." The final, like most finals in that day, covered the entire course and was made up entirely of matching and true-false items. I was shocked when I got my grade and discovered I had received a "B." When I went to see the professor, he

told me two students (both football players who rarely attended the class) had “knocked the top off” the final (and caused me to get the “B.”) I made a few inquiries and quickly confirmed what I suspected -- they had the test!

The second event occurred in a junior-senior level education course entitled, “Audio-Visual Aids to Education.” I was a double major in mathematics and government and I had enrolled in the course because I needed a three-credit course at a certain time and it was the only one I could find. Long story-short—it was all memory work about the advantages and disadvantages of the available AV aids to education. Imagine my surprise when, with a 94 average, I received a “C.” When I met with the instructor, he gave me two reasons. One, I was a sophomore and it was a junior-senior course. Two, I was not an education major. Almost 15 years later, I was doing a faculty workshop on that campus and the instructor, now a dean, was in the audience. I told the story without mentioning his name. He came up afterwards to say good things about the session and said, “I’m sorry about the grade.” I told him to “change the grade.”

The third event involving my undergraduate college was rather traumatic. Ten years after graduating, I returned to campus to interview prospective faculty for Miami-Dade Community College. The night I arrived, the social science building burned down. Both faculty and students were upset. Faculty, because all their old tests were in their offices and they would have to make new ones; students (especially fraternity and sorority members) because their test files were now useless.

The fourth event was studying for my major professor’s essay tests in government. This professor had three degrees from Harvard and was tough! I spent hours and hours studying **everything**—because he was known to be tricky.

These four events helped confirm my decision to include units on grading and cheating and caused me to think that if you told students what was important—without telling them what would be on the test, it would reduce their need to cheat and enhance the likelihood they would study and reduce test anxiety! These early experiences eventually led me to develop two faculty workshops I've done several dozen times that I entitled," Grade Your Grading Plan" and "The Many Ways Students Cheat—and How to Prevent Some of Them."

After college, I entered the Army (courtesy of ROTC) with a regular army commission. I spent my first five months in artillery schools at Ft. Sill and Ft. Bliss, then a month completing paratrooper school at Ft. Benning. I learned a lot from these experiences, but four things I have never forgotten. One was that when the reason to learn is made clear, you work harder. The second was that when instructors are really prepared, you can learn more, faster. The third was you learn by doing, not by listening. As I worked on putting together the first version of my college teaching course, I began thinking about how I could incorporate these discoveries in my new college teaching class.

The fourth was the waste of time required to produce lesson plans, something I, as Educational Officer, had to do. These were minute-by-minute scenarios of what I was going to do while teaching—and what my student soldiers were to do. I did one, realized how little value it was, and proceeded to teach my clerk how to do them. I later got a commendation for our lesson plans—but had never used them! What I had done was read the prescribed material, make a list of what the troops needed to know, develop some discussion questions related to these, and go teach!

A fifth learning event occurred when I completed paratrooper school. Although I didn't realize it until later, I learned how to take a difficult task like jumping out of a plane and landing without breaking anything, break it down into the steps needed to accomplish the big task, teach each step until it is completely mastered-- and then everyone can do the big task (in my case—jump three times in one day!)—without test anxiety!

After serving my three years, I resigned my commission and headed to Southern Illinois University, Carbondale, to be a residence hall director while I completed a master's degree in higher education (with a minor in psychology). Classes were pretty traditional (a mix of lecture-discussion and paper writing). One event in one course helped shape my thinking and indirectly contributed in a major way to ideas that were incorporated into the SOLO. Southern Illinois University was on a quarter system. One term I had to take a course on financing higher education—taught by a well-respected economics professor. He had us buy a *Principles of Economics* text and a newly published 600-page text on higher education finance. He then proceeded to "cover" both books—in 12 weeks, meeting three hours/week. When he announced that our grade would be determined by our score on a final covering both books, we were in shock. A classmate and I decided to study together. After two three hour sessions, I said "Russ, this is not working." I suggested we "make up" his exam and study only that. It worked, I set the curve, Russ was next, and a girl who studied all the time came in a distant third. Everyone else (15 students) was significantly below us. From this, I learned the frustration students experience when they have no clue about what is important to learn.

The other lesson I learned at SIU occurred in a course on the history and philosophy of education. It was team taught by two very well-known, very distinguished professors. They sat in chairs on either side of a desk in the front of the classroom. The first day they passed out a several page single-spaced bibliography (alphabetized by author). Then they began going through the list—talking about each author (they seemed to know them all) and commenting on the content of each book. It was a once-in-a-lifetime experience, but the only thing I learned was the difference between entertaining and teaching. (The only graded requirement was a paper—and we all got "A's.")

After completing my master's, I was accepted as a Kellogg Fellow at the University of Texas to work on my Ph.D. Once again, classes were a mix of lecture-discussion, and paper writing with an occasional exam. Two events had a major influence on my thinking about what worked—and what didn't work in influencing student learning. One event was related to the doctoral written exam and the second to the doctoral oral. At that time, the written exam was a three-hour, multiple-choice test covering every required course. When our group met to plan how we might study for it, we decided on a two-fold strategy. First, we would "debrief" everyone who had taken the exam in the last two-three years (it had not changed). We would put every question we obtained from them on 3"x5" cards. Second, we would all go through our notes, make up questions, put them on 3"x5" cards, then share them with our classmates. We all scored so high that the faculty had to make up a new test! As for us—we all breathed a sigh of relief and promptly erased all of it from our memory bank. This little memory exercise taught me how hard-working, motivated students could waste valuable time "cramming"—instead of using the time to apply, analyze, synthesize, and evaluate.

In contrast, the oral examination was a beautifully crafted, valuable learning experience that forced us to do everything the "writtens" didn't. We had to propose—in writing—with appropriate documentation, a significant change in a college. Then we had to present it to the faculty (who played the role of board members) and defend it. This forced us to: **find** material, **analyze** it, do a **synthesis** of it, **create** some new practice or policy, and then **present** (and defend) it. We met several nights to practice our presentations. From this, I learned "you get what you expect—provided you inspect" and the value of setting high expectations.

After completing my doctorate, I moved to Miami-Dade Junior College when I was Assistant-to-the Campus Director, then Acting Co-Campus Director. During my two years there, I received permission to teach (without pay) (at night and on weekends) a course entitled, "Introduction to Education." Some of the students were older than I was while others were recent high school graduates. Teaching that class taught me the value of pre-assessment, the importance of my determining—and letting students know-- what was important for them to learn, the need for me to learn how to write better test questions; and the amount of time required to be well-prepared for class.

I decided to leave Miami-Dade to find a job starting one of the community colleges that were being established at the rate of one per week. After turning down several offers I chose to go to Burlington County College, one of several new community colleges in New Jersey. I elected to go to Burlington because the president and his secretary were the only employees of the college and he was willing to allow me the freedom to develop the instructional program. The only advice he gave me was that he wanted our college to incorporate the best available knowledge about teaching and learning. As Dean of the

College, I was responsible for all instruction, registration, and the library-learning resource center. After developing the catalog--which included making decisions about the curriculum--including general education, I helped write the educational specifications for our new campus, and then focused my attention on recruiting and selecting our 35 charter faculty—and planning a paid seven-week pre-service training program for them.

Teaching students was one thing; teaching our charter faculty "how to teach" was something entirely different. This was especially challenging, because I had no clear picture of what I wanted to teach them. As I look back, **four** different events greatly influenced that first seven-week, pre-service workshop. One of these was a trip to visit several fellow deans at three California colleges—all with well-known reputations for innovations in teaching. These included Foothill, Mt. San Antonio, and Orange Coast. I returned with a briefcase full of materials and a head full of ideas—including very clear idea about "do's" and "don'ts." One of the takeaways was the need to have faculty include desired learning outcomes in their syllabi. Realizing how little I knew about writing learning outcomes, I went looking for good books on the topic and started reading. I happened across an excellent series of printed materials accompanied by slides and audio tapes prepared by Jim Popham and Eva Baker. As I worked through them, the outline of the pre-service workshop began to take shape.

Somewhere about then, one of our Board members told me about some "exciting" work going on in Willingboro, one of our school districts. When I followed up on it, I was amazed to find that they were a member of a consortium of K-12 districts working on improving student **learning**. Although there were several areas of focus, the one that most interested me was teaching faculty how to produce "learning packets." As I sat in

on their monthly meetings, it became very clear that faculty (like everyone else) "couldn't do things they didn't know how to do;" and for the Burlington faculty to incorporate "the best information about teaching and learning;" we would have to teach them what that meant—and develop policies and procedures which would facilitate—rather than inhibit their ability to incorporate these into their teaching. That recognition also led me to recommend significant changes in the educational specification for our new campus that would ensure a focus on learning, rather than teaching.

As a consequence, for a campus planned to accommodate 2000 students, the final plans included only six standard sized classrooms, two large group lecture halls (with a student response system)—several seminar rooms, four large independent study centers equipped with (then) state-of-the-art learning carrels (to be staffed with 35 hour-a-week instructional assistants), a testing center, and a faculty instructional development center. Because of what I had learned from the California colleges and the K-12 schools, I asked that the print shop report to the Director of Learning Resources and that we budget for two graphic artists to help faculty develop slides and transparencies. These decisions later proved to be some of the best decisions I could have made. Another decision (influenced by the California colleges) was to write a criterion-referenced grading system (built around the mastery of learning objectives) and include it in our first catalog.

The Popham-Baker materials and some adapted material allowed me to get through that first seven-week, pre-service workshop. The expression "you learn by teaching" proved to be prophetic!

The next major event in my evolution as a learning centered (versus teaching centered) instructor was the result of hiring a husband-wife team (Jean and Harlan Douglas) with a

background in instructional technology from the University of Southern California. Late that first term, I asked Harlan to go to lunch. During lunch, I asked him to become our Educational Development Officer. His major responsibilities would be to stimulate innovation in both curriculum and instruction, help me plan and conduct the next pre-service workshop for the 20+ new faculty we would be adding, and further my education about instructional design. It was Harlan who introduced me to instructional systems and it was Harlan who suggested we could do a better job, save a lot of money, and make faculty happy if we brought our new faculty in three weeks before classes for a two-week pre-service program, then gave them a week off to take care of personal business. It worked! By modeling what we wanted the faculty to do in their classes, we actually accomplished more (and got better evaluations) and saved money—which I transferred into my faculty travel account.

There were several other significant learning events. One came about as a result of focusing attention on a slowly growing number of adjunct faculty. When we started the college, we had employed a very small number of part-time faculty, primarily to help out in the fall when enrollments were highest. A concern about their preparation brought about by a remark that cost me a week to resolve led us to write a grant which we optimistically called "Development of a Model Training Program for Part-time Faculty." When it was funded, we designed five three-hour course Saturday morning sessions and put out a call for 15 "takers" (first come, first admitted). We paid them $15.00/session. The curriculum, based on division chair suggestions and an adjunct faculty needs assessment, was probably the first of its kind and a real success. Later student ratings showed no significant differences in student ratings between full-time faculty and those

15 part-time faculty. Once again, I had learned that when you use good instructional design principles, you can do more, better—in less time, than you would ever have dreamed.

Sometime during the 1969 school year, I received a 12 page publication by Bloom that was to have a lasting impression on me--and become a unit in my first course on college teaching. It was entitled, "Learning for Mastery" and summarized research that showed that under appropriate conditions, as many as 90% of students **could** learn at levels previously achieved by only the best students. One of the conditions was that students were told what they were to learn—not what was to be covered. I sent copies to all of our faculty.

Another major event was bringing two well-known consultants, Stu and Rita Johnson, to campus to do a three-day workshop on how to develop self-instructional modules. We were working toward developing a continuous exit approach in our developmental math, English, and reading courses in which we pretested students, then had them complete only those units where they had trouble. When they finished that course, we would then enroll them in the next course. Our major problem was a lack of self-instructional modules. The workshop on how to develop these was a tremendous success and gave our faculty the competence and confidence to develop learning modules that were self-paced. It also showed me, once again, how much motivated students can learn in a short period of time—if instructed properly. It also marked the first time I realized the benefit of the teach-practice-feedback sequence—as opposed to the teach-test model most faculty then used.

The last “learning” at Burlington occurred when Harlan showed me how to develop a “script” for incorporating media into teaching. Although a very simple idea—and one used for years by trainers in business, I had never heard of it. Knowing about it allowed me to later develop overhead transparencies that “walked” students through difficult learning tasks.

I left Burlington to join the National Laboratory for Higher Education, one of several federally funded regional laboratories—and the only one devoted to higher education. Although I was there only 11 months before the Center for the Study of Higher Education at Pennsylvania State University (PSU) came calling, I learned several things there that I later incorporated into my course on college teaching. The first was the value of soliciting and using student feedback to revise and refine instruction. The second was the absolute necessity to model what you want students to do.

All this was rolling around in my head as I started developing that first version of my PSU course on college teaching. During my three years at PSU, I taught the college teaching course once a year. It attracted graduate students from throughout the university, including several who had responsibility for selecting and preparing other graduate students to teach some of the freshmen courses that enrolled hundreds of students.

During that time, I, with several graduate students, developed a self-instructional module on how to develop a SOLO, one on writing, using and evaluating affective objectives, and one on Bloom’s taxonomy. My second year at PSU I, with a graduate student in the business college, did the first study on the effectiveness of SOLOS.

While at PSU I ran two PSU regional workshops on improving college instruction though the use of SOLOs. These attracted faculty from several states. Although the on-site evaluations of these were quite positive, I left PSU before I could do follow-up evaluations to determine if participants actually wrote SOLOs and, if so, if their use had made a difference in student learning.

After three years, I had decided what I wanted to do—go to a practitioner-oriented doctoral program where I could prepare experienced students with the knowledge, skills, and confidence to be effective leaders on their campus. By then, I had developed an impressive vita and a national reputation, so I had several universities to choose from. Why I chose Arkansas is another story.

APPENDIX B

Colostrum SOLO

Topics

1. Colostrum: what is it, why it is necessary, and how it is utilized by the foal
2. Importance of determining colostrum quality in the broodmare
3. Techniques of colostrum specific gravity analysis

Rationale

In the previous lab, we discussed the importance of the careful monitoring of the pregnant broodmare prior to foaling and the foaling process. Safe delivery is just the first step in producing a healthy foal. Many times inexperienced foaling managers overlook the importance of having the foal ingest high quality colostrum soon after birth. Colostrum is the mare's first milk, which contains antibodies that will provide immunity for the newborn foal. Immediately after a foal is born, the dam's colostrum should be tested to determine its specific gravity. The specific gravity of the colostrum is directly related to the level of antibodies available to the foal. In this SOLO, or Student Oriented Learning Outline, you will gain the knowledge to accurately analyze colostrum and will be able to make sound management decisions for a foal based on the results of this analysis.

General Instructional Goals

1.a. Understand how a foal digests colostrum and the impact colostrum quality on the foal's immune system.
2.a. Understand the importance of performing a post-foaling specific gravity test on a broodmare's colostrum, what constitutes good colostrum, and how colostrum should be stored.
2.b. Given the specific gravity of colostrum for a foal's dam, time frames and behaviors of the foal (time to stand, suckle reflex, time to first nurse) for the first 3 hours of life, determine what actions a foaling manager should take to insure a healthy foal.
3.a. Understand how common colostrum tests work and be able to name, contrast and compare tests for their accuracy, affordability and ease of use.
3.b. Understand how to determine the specific gravity of colostrum given any of those commonly used pieces of equipment.

(Appendix B continues)

Colostrum SOLO

Instructional Objective	Learning Resources	Special Instructions
1. a.1 Without notes or references, describe how a foal digests colostrum, and how colostrum quality affects the foal's immune system. 1.a.2. Without the aid of notes, describe why ingesting high quality colostrum is vital to a foal's immune system	1.a.1.Read: Colostrum: The Newborn Foal's First Line of Protection (HO1) 1.a.Read: Foal IgG (HO 2)	1.a. Write a one minute paper in class describing how a foal digests colostrum and the importance of the quality of colostrum. Discuss with the person to your right.
2.a. In your own words, describe how to determine colostrum quality and storage	2. PowerPoint: Colostrum Assessment	2. None
3. State sound management actions that should be taken given specific gravity of colostrum and foal behaviors	3.a.1.PowerPoint Lecture	3.Prior to lab, answer the questions on the *Colostrum Scenarios Worksheet*, and bring to class In class discuss *Colostrum Scenarios Worksheet.*

APPENDIX C

Advantages of SOLO Use from the Perspectives of Faculty Members and Students

Faculty	Student
Saves time the next time the unit is taught	Focuses available time on important topics
Focuses faculty attention on what is important	Allows students to work ahead
Encourages instructor to plan ahead	Provides specific prescriptions for learning problems
Self-quiz results help instructors recognize need for additional review	Facilitates and encourages independent learning
Fosters increased self-confidence	Fosters self-confidence
Provides a systematic approach which helps instructors diagnose where problems are	Facilitates their prioritizing the time available for study
Promotes active learning	
Facilitates development of a bank of objective-related items	
Promotes data collection for research projects	
Avoids student mistakes due to faulty note taking	
Saves classroom time spent on details of course management	

Note. From “Design and Evaluation,” by J. O. Hammons, 2011a, p. 185. Adapted with permission of the author.

APPENDIX D

Disadvantages of SOLO Use from the Perspectives of Faculty Members and Students

Faculty	Students
Requires time in writing and planning	Reduces the number of excuses they can make for poor performance
Requires advance planning by faculty	Increases the number of students who are likely to do well thus upsetting grade grubbers
Requires advance distribution of materials to students	
Requires prerequisite skills in writing instructional objectives	
Requires prerequisite skills in objectives-based evaluation instruments	
Can result in a positively skewed grade distribution, thus suggesting lowered standards	
Can discourage spontaneity in meeting unique student needs	

Note. From "Design and Evaluation," by J. O. Hammons, 2011a, p. 185. Adapted with permission of the author.

APPENDIX E

IRB Approval Form and Amended Approval Form

IRB Approval Form

MEMORANDUM

TO:	Kathi Jogan James Hammons
FROM:	Ro Windwalker IRB Coordinator
RE:	New Protocol Approval
IRB Protocol #:	13-02-467
Protocol Title:	*The Effectiveness of Equine Instructional Techniques*
Review Type:	☒ EXEMPT ☐ EXPEDITED ☐ FULL IRB
Approved Project Period:	Start Date: 05/15/2013 Expiration Date: 05/14/2014

Your protocol has been approved by the IRB. Protocols are approved for a maximum period of one year. If you wish to continue the project past the approved project period (see above), you must submit a request, using the form *Continuing Review for IRB Approved Projects*, prior to the expiration date. This form is available from the IRB Coordinator or on the Research Compliance website (http://vpred.uark.edu/210.php). As a courtesy, you will be sent a reminder two months in advance of that date. However, failure to receive a reminder does not negate your obligation to make the request in sufficient time for review and approval. Federal regulations prohibit retroactive approval of continuation. Failure to receive approval to continue the project prior to the expiration date will result in Termination of the protocol approval. The IRB Coordinator can give you guidance on submission times.

This protocol has been approved for 80 participants. If you wish to make *any* modifications in the approved protocol, including enrolling more than this number, you must seek approval *prior to* implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

If you have questions or need any assistance from the IRB, please contact me at 210 Administration Building, 5-2208, or irb@uark.edu

(Appendix E continues)

IRB Amended Approval Form

MEMORANDUM

TO:	Kathi Jogan James Hammons
FROM:	Ro Windwalker IRB Coordinator
RE:	PROJECT MODIFICATION
IRB Protocol #:	13-02-467
Protocol Title:	*The Effectiveness of Equine Instructional Techniques*
Review Type:	☒ EXEMPT ☐ EXPEDITED ☐ FULL IRB
Approved Project Period:	Start Date: 04/03/2014 Expiration Date: 05/14/2014

Your request to modify the referenced protocol has been approved by the IRB. **This protocol is currently approved for 80 total participants.** If you wish to make any further modifications in the approved protocol, including enrolling more than this number, you must seek approval *prior to* implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

Please note that this approval does not extend the Approved Project Period. Should you wish to extend your project beyond the current expiration date, you must submit a request for continuation using the UAF IRB form "Continuing Review for IRB Approved Projects." The request should be sent to the IRB Coordinator, 210 Administration.

For protocols requiring FULL IRB review, please submit your request at least one month prior to the current expiration date. (High-risk protocols may require even more time for approval.) For protocols requiring an EXPEDITED or EXEMPT review, submit your request at least two weeks prior to the current expiration date. Failure to obtain approval for a continuation *on or prior to* the currently approved expiration date will result in termination of the protocol and you will be required to submit a new protocol to the IRB before continuing the project. Data collected past the protocol expiration date may need to be eliminated from the dataset should you wish to publish. Only data collected under a currently approved protocol can be certified by the IRB for any purpose.

If you have questions or need any assistance from the IRB, please contact me at 210 Administration Building, 5-2208, or irb@uark.edu.

APPENDIX F

Participant Consent Form

The purpose of this study is to assess selected equine course material taught during 2013 based on unit objectives. Obtaining this information will be of value in determining what topics we should focus on, and what topics should be covered in alternate ways to enhance student learning. Participating in this study will require 10 minutes of your time, no more than four times throughout a semester, totaling a maximum time of 40 minutes. All information collected will be kept confidential to the extent allowed by law and University policy. Any data used for publication purposes will be reported as aggregate data and unit assessment answers will be entered into research data anonymously. Participation in this study is completely voluntary, and refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled and has absolutely no connection with class grades or future recommendations. In short, refusing to participate will not adversely affect your relationship with the equine staff, Department of ANSC, Bumper's College of Agricultural Food and Life Sciences or the University of Arkansas. If you choose to participate in this study, please sign below:

We appreciate your cooperation!

K. S. Jogan, M.S., P.A.S.
D. E. King Equine Program
University of Arkansas

Dr. James O. Hammons
Higher Education Leadership Program
University of Arkansas

Compliance Officer:
Iroshi Windwalker
Research Compliance Department

_____ _____

Signature Date

APPENDIX G

Emergency Care Lab Evaluation

This unit was developed in an effort to succinctly let you know the goals for the unit, and to map out a plan for you to achieve these goals. Please respond honestly to this questionnaire, so I can make any changes necessary to improve this unit. Do NOT write your name on this paper.

Please check the boxes next to the statement below on a scale of 1 – 5 where:

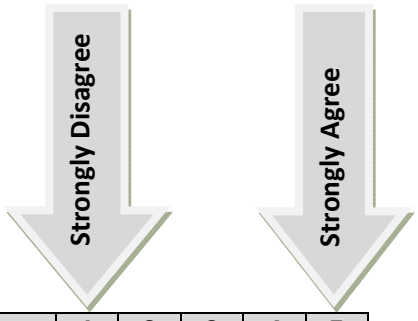
1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree



Question	1	2	3	4	5
1. I found that including the objectives prior to this unit made it easy for me to understand exactly what I was expected to learn.					
2. I found the way this unit was taught was helpful in learning emergency care.					
3. I found the self-quiz helpful when preparing for the test.					
4. I think that using a SOLO would be beneficial in other courses.					
5. The learning activities in this unit reinforced what we covered in class.					
6. I found the self-quiz to be a good indication of my knowledge on the subject of emergency care.					
7. I thought the *Emergency Scenarios Worksheet* was a good way to learn to apply what we learned in class and lab.					
8. The handouts associated with this unit were pertinent.					
9. The post-test helped me to prepare for the test.					
10. I liked the way this unit was lined out.					

11. Please briefly state what you liked most about this lab:

12. Please briefly state what you liked least about this lab:

APPENDIX H

Assumptions of ANCOVA and Effect Size

Assumptions of ANCOVA

There are eight assumptions of the analysis of covariance (ANCOVA). These eight assumptions, as they relate to this study, are discussed below.

First, the sample sizes were near equal (*n1* = 28; *n2* = 25), and there was no reason to believe the mild difference in size would affect the power of the tests conducted. Thus the first assumption of ANCOVA was met.

Second, as Tabachnick and Fidell (2007) assert, outliers can be detected by conducting a single multiple regression of the independent variable(s) and the covariate(s) on the dependent variable, by the grouping variable(s), and requesting the leverage statistic (*h*) for each observation. This leverage value was compared to the Mahalanobis Distance value, calculated by using the formula below:

$$h_{ii} = \frac{Mahalanobis\ distance}{N-1} + \frac{1}{N} \qquad h_{ii} = \frac{66849}{53-1} + \frac{1}{25} = 0.3165$$

The Mahalanobis distance was calculated to be 0.3165. Comparing this value to the leverage value produced by the multiple regression, only one observation was close to being an outlier, where *h* = 0.32. According to Tabachnick and Fidell (2007), this difference is negligible. Therefore, no outliers were detected, and the second assumption of ANCOVA was met.

The third assumption of ANCOVA was the normality of sampling distributions. This is the same as the normality of the distribution of means (Tabachnick & Fidell, 2007). The normality of the distribution of means is assumed to be true in the population, even if the sampling distributions demonstrate skewness. This was the case for two of the sampling distributions in

(Appendix H continues)

this study. Therefore, the third assumption of ANCOVA was met.

The fourth assumption, homogeneity of variance, assumes that the variance of the dependent variables is roughly the same at all levels of the independent variable. This can be tested by the *F*-Max test, which is the ratio of the largest variance to the smallest variance. Anything larger than a value of 3 should be investigated further. All of the *F*-Max ratio tests produced a value less than 3, so the fourth assumption was met.

Linearity, the fifth assumption, is tested by observing plots of the dependent variables individually, by level of the independent variable. These plots were created in SAS and viewed for deviation from linearity. None of the plots appeared non-linear or curvilinear. Therefore the fifth assumption was met.

Homogeneity of Regression, the sixth assumption, can be tested by observing the interaction term in the ANCOVA, which must be non-significant when using a typical alpha level (0.05). These tests revealed that the slopes of each dependent variable and the covariate were statistically parallel by group. This indicated that the assumption of equal slopes was met in each case.

The seventh assumption, correlation of covariate and dependent variables is tested by calculating each of these correlations in SAS. The correlations were positive between the covariate and the IgG exam scores and between the covariate and the emergency horse care exam scores. The correlations of the covariate with the colostrum exam scores, however was a very small negative value.

The eighth and final assumption is that of reliable covariates. There is no reason to believe that the high school grade point averages were not reliable.

(Appendix H continues)

While grade inflation likely exists, such inflation is not likely to differ significantly among the students.

Effect Size

In Table 8, there is an R-squared (listed as an Eta-squared) provided for each ANCOVA run. These can be interpreted as the amount of variance in the dependent variable explained by the independent variable, after controlling for high school grade point average. Cohen's *f* was calculated by hand in place of R-squared, because it has categories of magnitude as an effect size (Kotrlik, Williams, & Jabor, 2011).

The first ANCOVA run with IgG as the dependent variable has an R-squared of 0.08. When converted to Cohen's *f*, it has an effect size of 0.295. This is an effect size between medium and large (Kotrlik, Williams, & Jabor, 2011). The second ANCOVA run, with colostrum as the dependent variable, has an R-squared of 0.12. When converted to Cohen's *f*, it has an effect size of 0.295, which is considered between medium and large (Kotrlik, Williams, & Jabor, 2011).