# Developing Autonomy Through Laboratory Experience: A Case Study in Meat Science Curriculum

***Justin W. Rickard[1], Jessica L. Stephan and Richard W. Steffen***
***Illinois State University***
***Normal, IL***

***Bryon R. Wiegand***
***University of Missouri***
***Columbia, MO***

## Abstract

The absence of autonomous learning models within food animal science curriculum prompted this research linking food quality theory to consumer selection. Sixty-two food animal science students participated in this study to determine if laboratory experience enhances academic performance, comprehension and aids in development of learner autonomy. Students were randomly selected to participate in either a lecture (control; n = 31) or a lecture and laboratory exercise (treatment; n = 31) involving both subjective and objective analysis of pork loin chops. Eight correlations were found ($P < 0.05$) associating student analyses to objective measurements. Preference questionnaires indicated color was identified by students as a key meat quality cue, and is utilized during meat purchasing. Correlations between preference frequency and L*, a*, b* values for samples chosen based on color were -0.30, 0.06 and 0.05, respectively ($P < 0.05$). As lightness decreased sample preference increased, supporting lecture materials. Laboratory participation did not affect pre-test/post-test score differences ($P = 0.34$). Although academic performance was not enhanced through participation in the laboratory exercise, correlation analysis of students' subjective measurement of meat quality and objective instrument measurements suggested enhanced retention of lecture materials into the lab. These results support practical application of this model exposing students to self-education methods employable beyond the scholastic setting. Based on this, further research into the effect of laboratory experiences on academic performance and comprehension beyond the classroom is warranted.

## Introduction

Developing autonomy in students and employees is often the focus of instructional development as departments of education as well as governments continue to focus on the quality of teaching and training (Cranton, 1994). According to Holec (1980), autonomous learning can be described as the process of taking charge of one's learning. Hiemstra (1994) considered the idea of learner autonomy to be self-directed learning, or where the learner takes primary responsibility for learning decisions. Although these definitions are similar, multiple variations of the definition of learner autonomy may be found. This variety associated with the numerous definitions of autonomous learning leaves room for much diversity between explanations and reasoning in developing the idea of independent learners. In specific fields of education, curriculum design becomes important in order to foster autonomous learning while adequately teaching the necessary content. The methods by which this is accomplished may vary by discipline. For example, English as Second Language (ESL) teachers may utilize different methods of developing learner autonomy when compared to math instructors with the same goal of promoting independent learning techniques beyond the academic setting.

Food animal science courses within agricultural science curricula are designed to enhance comprehension of the technical aspects of food products with animal origins. These courses provide students insight into the processes of harvesting, cooking and consumption, and include coursework related to quality measurements for food safety and consumer perception. In many cases the overall goal of food animal science courses is

[1]Corresponding author,138 Ropp Agriculture Building, Campus Box 5020, Normal, Il 61790-5020 Phone: (309) 438-0285; Email: jwricka@ilstu.edu

two-fold; prepare students for employment in the food animal industry as well prepare them to be knowledgeable lifelong consumers of food animal products. Laboratory activities within these courses often require students to apply subject material received during lecture to complete hands-on activities (Parr and Edwards, 2004).

The overall goal(s) of food animal science courses may provide opportunities to develop and foster autonomous learning via laboratory experience. According to Schwienhorst (1998), autonomy is the capacity that the learner will acquire a psychological connection with the learning process that can be utilized into extensive situations. Based on this perspective, laboratory exercises in food animal curriculum may be beneficial in developing autonomy in that they can assist in bridging the gap between scientific information presented in lecture and the practical application of that information outside of the traditional classroom setting. One example of this may be found in meat quality evaluation. Meat quality is the result of a multitude of factors having relevance in both industry and purchasing habits of consumers of meat products (Aberle et al., 2012). This subject provides a unique opportunity for course instructors to attach "real-world relevance" to scientific information. As adults are exposed to information emphasizing the importance of the learning process, each individual is taking more responsibility for personal decisions, thus life planning also becomes a necessity (Edwards et al., 1998).

Agriculture as an industry would benefit from autonomous learners. Based on that, the following study was performed to evaluate the effectiveness of a laboratory exercise in enhancing students' knowledge and subject matter retention when compared to a traditional lecture-only setting.

## Methods

### Experimental Design

Research was conducted according to the Illinois State University (ISU) Institutional Review Board Guidelines following protocol approval. Undergraduate students enrolled in two courses; AGR 271: Foods of Animal Origin and AGR 285: Introduction to Meat Science, voluntarily participated in an experiment involving the visual appraisal of fresh pork loins treated with natural antioxidants. A total of 62 students from one AGR 271 class and two AGR 285 classes were chosen as the sample population for this study. Upon receiving written informed consent, each class was randomly divided into two groups participating in either a lecture (control) or a lecture and laboratory exercise (treatment), with 31 students in each group. Both treatment and control groups completed a demographic survey and a pre-test prior to a meat quality unit. The control group received only in-class lecture experience. In addition to lecture, the treatment group completed a laboratory exercise involving the subjective analysis of fresh pork loins treated with natural antioxidants at specified days of refrigerated shelf storage. It is important to note that the students completed the laboratory without direct instruction for the use of these cues, being advised and exposed to this information only during lectures within the meat quality unit. The treatment group also completed open-ended response questionnaires to determine which sample(s) each evaluator would purchase and the students' quality justification for that choice on each day of evaluation. Both the control and treatment groups completed a post-test following the meat quality unit. Pre-tests and Post-tests consisted of the same questions, which included information related to development, measurement, and evaluation of meat quality. Following the completion of this process, answers and explanations for test questions were discussed to both groups during lecture.

### Treatment Group Laboratory Exercise

Nine fresh pork loins, three per class, were used during the laboratory. The loins for each class were randomly chosen, measured and cut into twelve chops, 3.81 centimeters thick. The chops were treated with water (control), 5% rosemary, or 5% basil solutions of pure, edible extract oil and distilled water. A total of four chops within each loin were randomly selected for each treatment. The chop treatments have been found to conserve product color and increase shelf stability, maintaining the visual parameters of fresh pork loin chops (Sebranek et al., 2005). This allowed students to "judge" the full visual parameters of the chops for the duration of the study. Each treated chop was placed in a foam tray, wrapped with polyvinyl chloride (PVC) film, and assigned a sampling number according to the loin, chop treatment and chop placement within the loin. On days one, three and seven of refrigerated shelf storage, the chops were removed from a lighted retail meat cooler and evaluated by the treatment group of students. The schedule for one AGR 285 class required evaluations on days one, five and seven.

On selected days, the treatment group subjectively measured each sample for color, firmness and marbling. The student's subjective analysis was recorded based on anchored-line Likert scales for lightness, redness, marbling and firmness for each sample. Following student evaluations, a reflectance measurement device was used to calculate light intensity in order to quantify muscle color changes in the chops during storage. Objective readings on each sample were recorded based on light reflectance from a Hunter colorimeter to measure CIE L* (lightness), a* (redness) and b* (yellowness) values, calibrated against black and white reference tiles covered with the same packaging materials as used for the sample (Hunter Associates Laboratory Inc.) (Brewer et al., 2006; Hunt et al., 1991). These objective readings were taken to provide a point of comparison against the students' subjective analyses. The treatment group completed the open-ended questionnaires following each evaluation.

### Statistical Analysis

Quantitative data was analyzed using SAS/STAT® software Version 9.1.3 of the SAS System for Illinois State University Copyright 2010. A one-way analysis of variance model with fixed effects was used to determine if the fixed effect of student treatment (lecture/lab vs. lecture) influenced the mean difference between the pre-test and post-test scores as a measure of academic performance. A multiple comparisons follow-up test using least significant difference was used to compare the mean test score differences for the two groups. In order to evaluate comprehension and retention of lecture materials into the laboratory setting, students in the laboratory treatment group subjectively evaluated pork loin chops for multiple indicators of meat quality through the use of anchored-line Likert scale evaluations. Subjective evaluations were compared with objective instrument evaluations performed by the course instructor. Correlation analysis using PROC CORR was performed between each objective value and each subjective value to determine the degree of accuracy for the student evaluators. Pearson correlation coefficients were estimated for linear relationships between the student's subjective evaluations and the objective instrument evaluations from the laboratory.

### Qualitative Analysis

Qualitative analysis of the data was performed using responses from the open-ended questionnaires completed by the treatment group to determine if consumer preference could be linked to physical quality characteristics. Following each subjective evaluation, students completed questionnaires requesting they identify which pork chop sample(s) they would prefer to purchase as a retail meat consumer. The students were asked to justify the choice. Color was the key meat quality term used to perform the analysis. Visual color appraisals are in close relation to evaluations made by consumer, and are used to set the benchmark for many instrumental measurement comparisons (AMSA, 2012). Preferred samples were tallied for each class. For each preferred sample, the preference frequency was calculated based on the number of times chosen and the number of participants in each class. The preference frequency and the L*, a*, b* values were quantitatively compared using correlations to determine if consumer preference could be linked to physical quality measurements, thus promoting the use of techniques received through an autonomous laboratory and lecture into consumer scenarios.

The student demographic survey was used to establish background on the type of students involved in this study. Survey data was analyzed to determine the distribution of gender, age, grade level, and experience with food animal science classes in and outside of Illinois State University. The survey also assessed the average meat purchasing experience of the class by figuring the overall mean monthly meat purchases, as well as the mean monthly purchases of beef, pork, poultry, lamb and seafood.

**Table 1. Demographic survey results for grade level for all treatment and control groups.**

| Grade Level | Treatment | Control | Total |
|---|---|---|---|
| Freshman | 0 | 0 | 0 |
| Sophomore | 6 | 3 | 9 |
| Junior | 6 | 9 | 15 |
| Senior | 19 | 18 | 37 |
| Graduate | 0 | 1 | 1 |

## Results and Discussion

Tables 1-3 present the results from the demographic survey and represent an overall grouping of treatment and control participants from all three classes. Results of the demographic survey follow characteristics of the Department of Agriculture at Illinois State University. Forty-seven percent of the sampling population was female and 53% was male. Within the treatment group, 61% of the students were males, compared to the control group with 45% males. Seniors represented the majority of the sampling population and also accounted for the majority in both the treatment and control groups (Table 1). Agriculture business majors/sequences represented the majority of the students in the sampling population and in both treatment groups, followed by agriculture industry management and food industry management (Table 2). Only seven students total, three in the treatment group and four in the control group, had taken the corresponding food animal science class (AGR 285 if in AGR 271, or AGR 271 if in AGR 285) at ISU, or had taken a similar class at another institution.

The sampling population had an average of 3.6 total monthly retail meat purchases, with beef representing the most purchased meat category. Poultry was the next highest, followed by pork, seafood and lamb. Both treatment and control groups followed similar patterns. The control group averaged 3.9 overall monthly meat purchases, with 2.1 average monthly pork purchases. The treatment group averaged 3.3 monthly meat purchases, with a monthly average 1.9 pork purchases (Table 3). These results are in contrast with information reported by the United States Department of Agriculture, which has shown downward trends in beef consumption as per capita consumption of poultry has risen over the last few decades. More poultry is consumed per person than any other meat (AMI, 2015). Often, consumption of certain types of meat is largely dependent upon geographic

**Table 2. Demographic survey results for majors/sequences for all treatment and control groups.**

| Major / Sequence | Treatment | Control | Total |
|---|---|---|---|
| Agriculture Business | 10 | 8 | 18 |
| Agriculture Industry Management | 8 | 6 | 14 |
| Food Industry Management | 4 | 5 | 9 |
| Agriculture Education | 3 | 3 | 6 |
| General Agriculture | 3 | 1 | 4 |
| Animal Science | 1 | 3 | 4 |
| Agriculture Science | 1 | 1 | 2 |
| Family and Consumer Science | 0 | 1 | 1 |
| Business Administration | 0 | 1 | 1 |
| Public Relations | 1 | 0 | 1 |
| Construction Management | 0 | 1 | 1 |
| Horticulture | 0 | 1 | 1 |

**Table 3. Demographic survey results for overall average monthly retail meat purchases and by categories for all treatment and control groups.**

| Categories (# of purchases) | Treatment | Control | Total |
|---|---|---|---|
| Overall Monthly Purchases (avg.) | 3.30 | 3.90 | 3.60 |
| Beef | 3.38 | 3.60 | 3.49 |
| Poultry | 3.00 | 3.30 | 3.15 |
| Pork | 1.89 | 2.05 | 1.97 |
| Seafood | 0.62 | 1.22 | 0.92 |
| Lamb | 0.07 | 0.13 | 0.10 |

region. Purchasing trends exhibited in this study could be related to relatively high consumption patterns of red meat within the geographic regional location of the participants.

Pearson correlation coefficients indicated eight significant linear relationships between the subjective student analysis and the objective instrument analysis ($P < 0.05$) (Table 4). These results suggest that students in the laboratory were able to accurately evaluate the pork loin chops based on multiple meat quality indicators. Qualitatively, color was the most frequent cue identified and used by the students for consumer preference which is similar to results reported by Grunert et al. (2003) and AMSA, (2001) stating that color is the main justification consumers use to purchase meat products. Using the frequency of samples preferred because of color, correlations between the preference frequency and the L*, a*, b* color values were -0.30, 0.06 and 0.05, respectively ($P < 0.05$). As the degree of lightness decreased, preference for the samples increased, indicating darker samples had higher preference. As a* and b* increased, preference increased slightly. Given the weak correlation for preference and a*, b* the degree of redness or yellowness had very little effect on preference. According to Frederick et al. (2003), low L* values demonstrate higher consumer preference. The students were able to distinguish the quality of the samples based on quality information presented during lecture within the semester. These results concur with Grunert et al. (2003) advising that as individuals are continually exposed to applicable quality information and the product selection process, they will develop the required quality cues used during the selection process for the desired characteristics.

Analysis of variance results indicated no significant test score differences (post-test score minus pre-test score) ($P = 0.34$). Student treatment did not affect test scores to indicate enhanced academic performance of evaluators in the laboratory when compared to the lecture-only control. Laboratory exercises have been cited as playing a role in developing not only students' conceptual understanding of science, but also in developing students' interests (Wu, 2013). However, in the current study, these parameters were not directly measured. Efforts to foster development of autonomous learning, such as the one presented within the food animal science curriculum, are designed to aid the growth of learners into valuable and practical supervisors of personal learning (Sherman, 1985). The students demonstrated comprehension of quality characteristics through a process fostered by repeated exposure to the information, which is in agreement with Grunert et al. (2003). Adoption of this theory becomes apparent in meat product consumers where quality measurements are developed through a "learning by doing" experiential process. The majority of the students' learning in science actually takes place outside the classroom (Ramsey and Edwards, 2004). Qualitative analysis completed by Rhykerd et al. (2006) concluded that participation in a crop production and marketing contest suggested greater comprehension of principal agronomy, commodity marketing, and mechanization concepts. The authors proposed participation in the contest encouraged experiential learning requiring the students to make actual decisions and observe the direct outcomes for those decisions. Findings of the current research suggest that this curriculum model may be used to connect gaps between instructor and student.

## Summary

The expected annual per capita consumption of red meat and poultry by the end of 2008 approximates to 22 pounds of retail weight, roughly $573 per person, per year. Projections for 2016 indicate the per capita consumption will increase to $656 per person (USDA, 2007). Increasing trends in meat consumption indicate the need for food animal science curriculum that will prepare both future food animal industry stakeholders as well as future consumers of meat products. Food animal science courses present an opportunity to utilize laboratory exercises to provide "real-world" scenarios relating science to everyday experiences such as meat purchasing.

Similar to discussion provided by Clark et al. (2010) in which the authors state experiential learning in tech-

**Table 4. Results for Pearson Correlation coefficients between the objective[z] instrument analyses and subjective[y] student analyses for all three classes.**

| Variables | L*[z] | a*[z] | b*[z] | Light to Dark[y] | Pink to Red[y] | Firmness[y] | Marbling[y] |
|---|---|---|---|---|---|---|---|
| L*[z] | ——— | | | | | | |
| a*[z] | 0.19** | ——— | | | | | |
| b*[z] | 0.30*** | 0.54*** | ——— | | | | |
| Light to Dark[y] | 0.39*** | 0.15* | 0.08 | ——— | | | |
| Pink to Red[y] | 0.37*** | 0.13* | 0.06 | 0.97*** | ——— | | |
| Firmness[y] | 0.06 | -0.05 | 0.19** | 0.06 | 0.07 | ——— | |
| Marbling[y] | 0.26*** | -0.12* | 0.15** | 0.19*** | 0.22*** | 0.09 | ——— |

[1]Pearson's Correlation Coefficients test on objective and subjective analysis

[2]*, **, ***,significance at the p<0.05, p<0.01, or p<0.0001, respectively using Pearson's correlation coefficients

[z]Objective instrument readings based on Hunter Color Scale Values

L*: ranges from dark (0) to white (100)

a*: positive numbers red; negative numbers green

b*: positive numbers yellow; negative numbers blue

[y]Subjective analysis using Likert scale values completed by students

Color: degree of light to dark

Color: degree of light pink to dark red

Firmness: degree of soft to very firm

Marbling: practically devoid to abundant

nical education programs may differ from true experiential learning, it may be difficult in food animal curriculum to provide true autonomous learning experiences. Although the laboratory exercise reported in this study may not have been definitively autonomous in nature, these exercises may assist in the development of autonomous learners. In this study, associations between the subjective and objective analyses indicated students were able to evaluate pork quality using information presented within lectures during the semester and possible from past experiences involving pork product selection. Students successfully identified and utilized the main meat quality cue of color. This suggests that quality cues can be developed and applied to real-life scenarios in food animal curriculum utilizing laboratory exercises.

In accordance with Hiemstra (1994), a more qualitative approach was used during this project to support the theoretical aspects of autonomous research. The process by which the students were able to take materials obtained in class lecture and apply them to laboratory activities suggests autonomous learning skills, as recommended by Sherman (1985). Exposing students to this process allowed students to become equipped with a method of self-education employable beyond the scholastic setting. However, further research into the benefit of laboratory exercises in food animal curriculum is warranted.

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