Optimizing the Human Diet in the Classroom: A Critical Thinking Oriented Semester Project for Ag Econ Students

By

Amber Remble
University of Wisconsin — River Falls
Amber.Remble@uwrf.edu

Roman Keeney
Purdue University
rkeeney@purdue.edu

Selected Paper prepared for presentation at the Southern Agricultural Economics Association’s 2015 Annual Meeting, Atlanta, Georgia, January 31-February 3, 2015

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Introduction

Modern information technology has not only facilitated an active learning environment but has led us to a place where student experience may be highly differentiated. In recognition of this, those driving the development of higher education have increasingly focused on learning outcomes as opposed to curriculum uniformity or stability for ensuring student development is consistent with the goals of university education (Tiwari et al. 2006).

At the forefront of these learning outcomes is the development of critical thinking. Critical thinking has been prioritized in examinations of higher education objectives and performance measurement, for the prominent place it plays in student success. A more globalized and rapidly adjusting society requires that we not prepare students with knowledge of the current state of the world, rather that we prepare them to internalize information, analyze that information, and form relevant conclusions.

Approaches to incorporating critical thinking are by definition non-standard. Subject matter will determine the extent to which critical thinking may be incorporated into the curriculum. Economics courses represent a natural avenue for developing student critical thinking skills. While no standard approaches have emerged for critical thinking incorporation in the literature, the one recommendation that emerges is that the practice must be intentional (Greenlaw and De loach 2010; Tsui 1999). As such, research into critical thinking instruction has largely followed a taxonomic approach, identifying core components that can be used in development of critical thinking exercises as well as used for monitoring student performance and achievement of learning outcomes.
Critical Thinking in Higher Education

The taxonomic development of critical thinking in higher education is summarized in Facione et al. 1995. The seven components given in Table 1 reflect a systematic summary approach of a large survey conducted to identify the characteristics evidenced by sound critical thinkers. These seven components represent key items for consideration in course development where critical thinking development is sought. An active learning environment that is intentional in progressing students through the components from lower level components such as systematicity and requires further development to the final maturity level will provide the most potential for critical thinking development as a learning outcome.

Table 1. Critical thinking subscales for evaluation

<table>
<thead>
<tr>
<th>Critical Thinking Component</th>
<th>Definition</th>
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<tr>
<td>Inquisitiveness</td>
<td>Intellectual curiosity without apparent reward beyond learning.</td>
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<tr>
<td>Open-mindedness</td>
<td>Tolerance of multiple views and sensitivity to personal biases that may intrude into reasoning.</td>
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<tr>
<td>Systematicity</td>
<td>Organization and framework based inquiry.</td>
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<tr>
<td>Analyticity</td>
<td>Valuing the application of reasoning and the use of evidence in problem approaches.</td>
</tr>
<tr>
<td>Truth-seeking</td>
<td>Eagerness to seek the best knowledge for the given context.</td>
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<tr>
<td>C.T. Self confidence</td>
<td>Trust in the soundness of one’s own reasoned judgments.</td>
</tr>
<tr>
<td>Maturity</td>
<td>Approaches problems with a sense of inquiry leading to conclusions while recognizing that context dependency may lead to many plausible outcomes, that many problems may be ill-structured, and that available information will limit degree of certainty.</td>
</tr>
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</table>

Source: Facione et al. 1995.

The factors identified by Facione et al (1995) map naturally the development of economic thinking. Everyone is an economist in the sense that they make choices subject to constraints, so the subject is immediately relatable, but much of economics education never advances well beyond the systematicity aspect, in which we place economic outcomes into a formal context to judge the rationality of decision making. No standard approach has been uncovered in the extant literature, rather the idea of being intentional and pursuing a course where active learning assignments are
mapped to the taxonomy is proposed by nearly all researchers examining critical thinking in higher education.

*Critical Thinking in the Ag Econ Classroom: A Semester Length Program in Critical Thinking Instruction*

With the above guidance in mind, we develop and present a semester length project idea for upper division Ag Econ students in math programming. Math programming is one of the more complicated courses for undergraduate Ag Econ students but offers a significant opportunity to cover the full critical thinking component set presented in table 1. A semester length project that steps students through the critical thinking development components offers the greatest opportunity to influence student development as well as allowing instructors to monitor progress in an iterative process.

In the following subsections, we develop such a project organized around Stigler’s (1945) classing formulation of the human diet problem. Each student is required to understand the original diet problem as Stigler presented it in terms of subsistence cost. Replication using data collected by students is a central part of the assignment, but represents only an intermediate step towards the full critical thinking development of the final project when the student poses their own economic question that can be answered by analysis of the optimal human diet and communicates those results in context with policy implications.

**Lecture Topics that Support Project**

The final course project incorporates concepts taught and learned throughout the semester of the course. To complete the Diet Problem, students will need to have an understanding of components required to set up and solve a basic linear programming problem. This includes identifying the parameters (given information) and variables that will adjust as the problem is solved. Students will have practice on setting up objective functions and constraints using appropriate parameters and variables. The course forces students to begin this practice with mathematical
formulas prior to incorporating them into a Microsoft Excel spreadsheet to solve with the Solver Add-on.

Once basic linear programming components have been covered, the course then walks students through specific linear programming problems including diet problems. This topic addresses the objective of minimizing costs when paying for food while meeting certain nutrient requirements (e.g. calories, protein, etc.). Composing appropriate nutrient constraints is highly emphasized as it not only shapes the result but is key to making the problem realistic and informative. Identifying binding, as well as the most limiting, constraints will also be lectured upon in class and practiced by students in lab exercises prior to the project.

Another topic that will be covered to support the execution of the final project will be sensitivity analysis and the interpretation of shadow prices of the constraints. This topic is one of the more advanced in the course and will therefore be presented continuously throughout the semester in lectures and lab exercises. Sensitivity analysis in the final project requires the students to examine the impact of each of their constraints and how it directs the solution.

**Phase One - Assignment on Data Collection**

The first phase of the project is collecting data that will be used in the linear model. This exercise serves several purposes in that not only is it a means for the students to obtain data that will be used for the model but it is a simple lesson on interactive data gathering. Undergraduate students generally have little experience with numerical data gathering and this is phase is a primary exposure to that process in the sense that they are directed on the information needed.

The data gathering phase is typically been assigned as a group assignment, composed of two to three students. Students are asked to collect nutrition information for 30 food items. This information for each item includes price (dollars per serving), calories, fat (grams), sodium (mg),
carbohydrates (grams), fiber (grams), protein (grams), vitamin A, vitamin C, calcium, and iron on a per serving basis. They can gather this information from grocery stores, the internet, or other means. An Excel spreadsheet is provided by the professor for students to enter their collected data into a specified format. Once entered, the group is required to email their spreadsheet to the professor. Evaluation is based on the number of food items observed, the appropriate data, per-serving conversion, and proper formatting specified. Students are typically given a week to gather and submit the data. It is imperative that meet the deadline for submission so that their data can be included in the class databank. An example of the spreadsheet used for data gathering is depicted in the image below.

![Figure 1. Example of data collection template](image)

**Phase Two - Assignment on Working with Data and Preliminary Model**

The second phase of the final project consists of a cost minimization Diet Problem lab exercise assigned by the professor after she has compiled the food data information from all groups into a single databank spreadsheet. This assignment is executed during lab meeting with the professor’s guidance and availability to answer questions. The assignment is to solve the Diet Problem for a specific demographic (30 year old, mild active male), thereby using specific nutrient requirements to shape the constraints. The nutrient requirements are on a daily basis and come from USDA recommended daily allowances. These assignments are submitted individually as opposed to group work. Each student must use data for 20 food items of their choosing from the class databank to use in the program.
Instructions are given on proper set up of the problem including where to enter the objective and constraint formulas. Part of the students’ task is entering proper formulas for solving. Because they are dealing with a large number of variables relative to past labs and examples, identifying the activity cells and using them in the formulas is a crucial lesson.

Once formulas are correctly entered and the model is set up in the spreadsheet, students are asked to identify which food items in their set provide the most cost-effective nutrient per serving. This is done by dividing each nutrient by the price for each food item. For example, students can find the most cost effective calorie food item by dividing calories by price per serving for each item. The item in which they obtain the most calories per price will be the most efficient. It is assumed that the most cost efficient items will be used as solutions to the model. This activity forces students to observe their data before any model solution, as well as make predictions on the solution.

Excel Solver will then be used to solve the Diet Problem. Students must identify the total cost and the amount of each food item that is suggested. They are then asked to comment on the practicality of the solution. Questions are also posed on binding nutrient constraints and interpreting shadow price(s). This exercise provides students with a basic example of setting up and solving a
least cost Diet Problem and identifying relevant information. They can use these methods for the final phase of the project.

**Phase 3 - Assignment on Model Construction, Replication of Least Cost Diet**

The final phase of the project asks students to come up with their own version/modification of a least cost Diet Problem. Students must compose a diet question they can answer. These questions can either pertain to them personally or be completely arbitrary. These specific questions will not only influence the constraints used in the model but also the food items chosen as well. The variety of questions students have proposed has been impressive.

For example, some students decide to keep the same nutrient constraints from the lab but modify the food choice (e.g. only fast food consumption, only yellow food items). Others modify the nutrient constraints (e.g. consuming at least 3000 calories per day, college-age nutrient requirements for females). Some students have gotten creative with their modeling and added in non-nutrient constraints (e.g. the diet has to contain at least one serving of ten different food). The various questions force students to properly modify the model. Students are given one week to email the professor their proposed problems and how they plan to modify the model.

A lab meeting period is used for students to construct their model and use the professor for any guidance with spreadsheet work and interpretation. Once set-up properly, they can then proceed to solving the model with Solver Add-On and writing the paper as the final step of the project. The interval between the last lab session used for the project and the paper submission deadline is typically between seven and ten days. This allows the students to make necessary adjustments should problems arise or if the model is unsolvable due to complicated constraints, as well as write the paper effectively.
Assignment on Communicating Results

One of the most important lessons emphasized in this course is the ability to identify relevant information and to tell a story with it. For the final phase, students are required to write a paper on their model. Proper formatting for papers and presentations are covered in lecture in the course. It is important for students to be structured and concise when explaining the project. Therefore, it is required that students begin their paper by posing the question they are setting out to answer. They then must list the food items used in their data set and describe the constraints used and their importance. Students are encouraged to execute and discuss pre-model data analysis such as finding cost-efficient items for each nutrients. Again, this is to get them familiar with the data and the nature of the food items they’re using. They must also discuss the motivation behind their food selection as this will most certainly impact the model and force them to justify their pre-modeling decisions.

Discussion of the results is also required. Again, the most important results are the final costs and the level of consumption of the food items being used. Writing about food items not used in the solution is penalized. Other results discussed included identifying the binding constraints and interpreting their shadow prices. Students are also encouraged to comment on the practicality of the results and whether the model presents a realistic solution. Lastly, the students should comment on how they could modify the model to make is more realistic if desired.

Again, the paper should be a concise story of the question the student set out to answer, how they attempted to answer it, and the answer the obtained. The paper is required to be no less than four pages and no more than six pages as this has historically been a sufficient length to complete the task mentioned in concise fashion. Examples of the paper format and a completed paper from a student in a past semester is provided to the students.
Concluding Discussion

The steps involved in the semester long assignment described above map well to the critical thinking paradigm laid out in table 1. Beginning with data collection, students are put into groups and asked to collect factual data for use in the project. Their data is then combined to form a large data set representing the collective effort of the class. Working in a group fosters open-mindedness as students must work within the group dynamic, being exposed and respecting others ideas. When the full data set is collected, students examining this will see a large set of foods and begin to see that other student groups had completely different ideas about which food data is most interesting to collect. The data collection assignment as well as the calculations of cost per nutrient index measures for different foods fosters analyticity. The reasoned, evidence based ordering of foods in a simplified manner (i.e. ranking foods with the most caloric content per dollar) is an important step in moving students from broad ideas to quantitative reasoning, using data and calculations to form expectations.

Replication of the Stigler (1945) least cost provides students reinforcement in systematicity. Students are required to take the data and place it into a formal framework with evidence based information on constraints. This replication assignment is also an endeavor in truth-seeking, as students are given a posed problem and are allowed to discover that the naïve per dollar nutrient calculations they previously calculated provide a weak approach compared to that of the model that evaluates the full set of diet tradeoffs.

The final paper communicating a new problem, developed by the student after replicating the least cost diet problem, is designed to cover inquisitiveness, critical thinking self confidence, and maturity. The inquisitiveness component is covered by the problem statement development centered around a new question posed by the student after examining a diet model and an extensive set of
data on food nutrition. Critical thinking self confidence and maturity are developed in the iterative writing process by which students provide written communication of findings and are urged to form conclusions that are supported by evidence. Exceptional projects will move from reporting results and a simple answer to posed question into the broader policy realm, identifying the contribution of their work and how it would need to be recast or expanded to have greater impact.

It is important to keep in mind, however, that the learning objective is twofold. Students in the course are required to learn the linear programming technique and best practices for data collection. But the full breadth of the assignment is designed to prepare students for the unknown problems they will need to encounter using critical thinking skills demonstrated here in the context of a limited problem. Pushing the assignment all the way to the written communication phase is identified as a critical element in lasting critical thinking development in the classroom (Greenlaw and De loach, 2010).

To date work has focused on developing the course project in line with best research about critical thinking. Future development will involve student assessment of the table 1 properties to understand the learning outcome success involved in the project. Scales such as those offered in Facione (1995) and Tiwari (2006) will be important for further understanding and taking the study of critical thinking in ag econ classrooms from the developmental to empirical phase.
References


