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AGRO 204: Resource Efficient Crop Management

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Peer Review of Teaching Program 2018-2019 – Benchmark Portfolio

AGRO 204: Resource Efficient Crop Management

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Abstract

Resource Efficient Crop Management (Agro 204) is a high enrollment course taken by a diverse range of student majors across the College of Agricultural Sciences and Natural Resources (CASNR) at the University of Nebraska-Lincoln. Learning outcomes focus on teaching crop management principles and processes, systems-thinking, data analysis, synthesizing current information, and evidence-based decision-making. This benchmark portfolio critically assesses student learning toward these outcomes, with an emphasis on a particular assignment that required students to work with the farming simulation platform, APSIM. The Agricultural Production Systems sIMulator (APSIM) is a freely available computer program that is an internationally recognized simulator of agricultural systems. In five course periods throughout the semester as well as through online videos and materials, students were introduced to the APSIM platform. The assignment assessed in this portfolio required students to set up their own "experiment" with a hypothesis that could be performed and analyzed using the APSIM platform. Ninety-one percent of student responses in the assignment demonstrated that students were able to explain a process underpinning crop management (such as differences in crop water use with different crop rotations) which was a major goal of this assignment. In addition, a post-assignment survey found that 67% percent of students agreed with the statement that "The simulations helped me understand the interaction of controllable and uncontrollable factors that affect yield." Based on the simulations, students reported how they discovered a range of new potential management understandings, from the impact of planting dates, soil types, climate change and crop rotations on various agronomic outcomes such as crop yield or nutrient loss. Many students further reported gaining awareness of the software and related platforms such that they could envision using such a platform to recommend crop management decisions to others or for use with their own farming operations. A pre- and post-assignment survey revealed that students gained confidence in hypothesis development, data analysis, and evidence-based decision-making from the course. Many students reported challenges with the computer program, and a number of improvements will be made in the future to facilitate student experiences and learning.

Course overview

Resource Efficient Crop Management (Agro 204) is a high enrollment 200-level course that introduces students to the basics of crop management principles including how to utilize natural resources (sunlight, water, soil) and inputs (seeds, fertilizer, herbicides). Historically the course has focused on crop production principles of the major commodities grown in Nebraska: corn, soybean and wheat. It is a required course for students majoring and minoring in agronomy, as well as for other majors across CASNR including integrated science majors (CUSP Scholars from Rwanda). Students span from freshmen to seniors, although most are sophomores or juniors (Figure 1). Spring 2019 was my second time teaching the course and there were 103 students enrolled in two sections, with 52 and 51 students each. The course met twice weekly for 80-minutes in a classroom with round tables of five seats each.

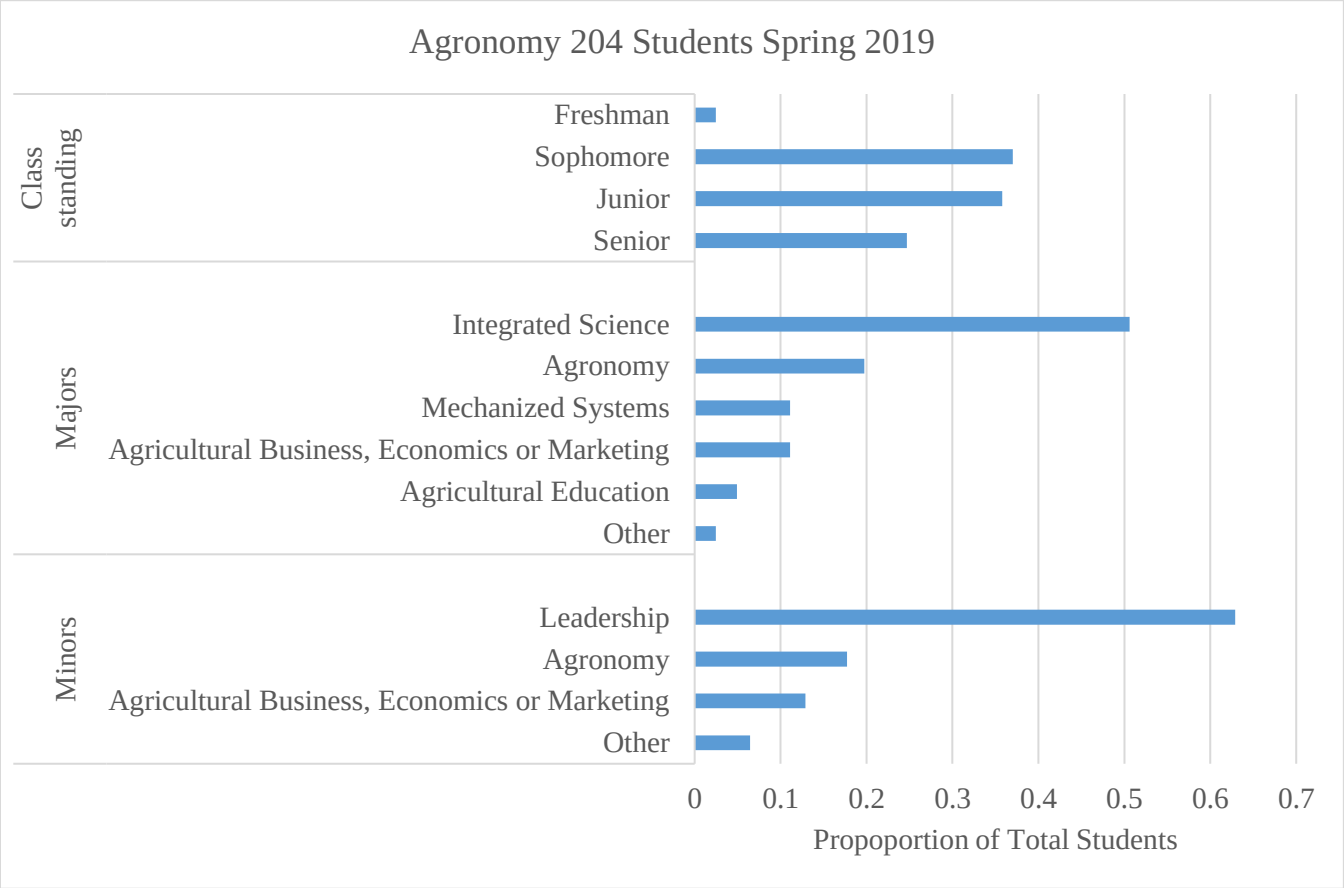

Figure 1. Overview of majors, minors and class standing for spring 2019 Agro 204 enrolled students.

Course goals

Instructor goals

My goals in building this benchmark portfolio are to ensure that I am clearly articulating learning outcomes consistent with my own expectations for student learning and departmental learning outcomes, and that I am designing and executing assessments to meet these learning outcomes. Learning outcomes from the course and the Agronomy and Horticulture Department are outlined in Table 1. In summary, my learning outcomes are for students to think critically about *principles* and *processes* of crop management rather than recipes for production, they understand that "resources" include the natural environment and not only external inputs, and that they work authentically with peer reviewed articles and publicly available data to better understand how new knowledge about agriculture is generated. My intentional emphasis on principles and processes rather than recipes is in part to align with Departmental learning outcomes, as well as the current student enrollment. There is a range of understanding about the basics of the crop production, and in particular, existing knowledge of crop production in the state – some students are extremely familiar and others are very unfamiliar. Further, given the large number of international students currently enrolled, a strict focus on memorizing information about the Nebraska crop context would not meet the needs of all students, nor do I believe it would be the most appropriate approach for their future careers in the rapidly changing field of agriculture.

Improvement Rationale

I am interested in improving Resource Efficient Crop Management to ensure that students are learning the material in an effective manner and that activities are tiered within the course and within the overall curriculum for Agronomy Majors and CASNR students. My first opportunity to teach the course was very time constrained and the prior materials were difficult for to make my "own" with the limited time I had to prepare. In 2019, I created and executed three semester long assignments that culminated in the latter part of the course which were new and meant to meet course and departmental learning outcomes as described in Table 1: 1. A group project where students designed a mix of different cover crop species to optimize biomass production and diversity, and then grew their mixes in greenhouse and field experiments; 2. Analysis and summary of a peer reviewed scientific journal article related to a crop management topic of their choosing; 3. A two part assignment that required students to plan and execute an experiment using a farming simulation computer program, which is the primary emphasis of this benchmark portfolio.

Teaching Methods

Methods overview

The course is taught as a combination of lecture, small group or individual activities (e.g. calculations, reading/answering questions), and in-class quizzes. Lectures are meant to introduce or review material. Lectures typically include interactive questions integrated at regular intervals to further engage students in the material. Small group activities are meant to reinforce learning presented in the lecture and to engage students in applying new knowledge and concepts. In spring 2019, the course utilized additional small group activities conducted both at field experiments on East Campus (2.5 class periods) and the teaching greenhouse (2.5 class periods). Quizzes are meant to test knowledge and to ensure that prior material inside and outside of class has been covered.

Outside activities and course materials

Outside of instruction time, students were assigned weekly reading material including chapters from a textbook, peer-reviewed articles, Government materials and Extension publications. The textbook utilized in the course is "Introduction to Agronomy: Food, Crops, and Environment (2nd Edition)" by Craig C. Sheaffer & Kristine M. Moncada. All course readings are made available on Canvas. In spring 2019, there were three major homework assignments for students to complete in the course. The first was a three part assignment where students worked individually to summarize a peer-reviewed article of their choosing (related to precision agriculture, cover crops, nutrient management, production trends, or other topics) and to produce a short screencast video that their colleagues viewed and provided feedback to them. A list of approximately 30 potential articles were provided to students for them to select from for this assignment, and in total the three parts of the assignment were worth 100 points (out of a possible 735 in the class, or approximately 14% of final grades). The second assignment was completed by individual students in two parts and required students to complete their own "experiment" using a farming simulation computer program. Assessment of student learning from this assignment is primary emphasis of this portfolio and is explained in further detail below. The two parts of this assignment were worth 100 points or approximately 14% of final grades. The third assignment, the "cover crop challenge", was completed by groups in two parts. For those series of activities, students worked in groups of 3-4 students to select a mix of cover crop species that would was planted in the greenhouse and at an experimental site on East Campus, with a goal of selecting a mix that would produce the most growth and diversity of plants. These assignments were worth 150 points or approximately 20% of final grades. The learning outcomes associated with these assignments are in Table 1 and further description of the assignments can be found in the Syllabus included in Appendix A. In total, these major homework assignments in the course we were worth 350/735 points, or approximately 48% of final grades.

In sum, course materials included the textbook, additional reading materials, and the computer program required for the simulation assignments. Outside activities included the homework assignments previously described, which required students to work with computers and to manage their cover crop experiment in the greenhouse.

Rationale for methods, activities and materials

The course was revised significantly in spring 2019 from my first time teaching it in spring 2018. A major change was that I chose to teach the course in two sections rather than one in order to have more direct contact with students, and I selected a classroom that is well designed for small group activities. I also received feedback in my spring 2018 course evaluations that students sought more practical or "hands on"

activities in course. The most direct way that I sought to address this feedback was through the cover crop challenge, which provided students with the opportunity to create and grow their own cover crop mixture. The field activities during course time were also meant to provide students with more hands on experience with crop and soil management as well as experience working with the data that they generated. My goal in having students work through the farming simulation assignments was to gain firsthand experience with agricultural technology, to generate and analyze their own data and to learn more about the complexities of farming systems. The peer-reviewed article assignments sought to ensure that students are familiar with the process by which new knowledge about agriculture is generated. More about how the assignments aligned with learning outcomes can be found in Table 1. Overall, learning outcomes centered on introducing or improving student familiarity with systems-thinking, data analysis, synthesizing current information, and evidence-based decision-making.

Course links to broader curriculum

Agronomy 204 is a required course for Agronomy majors and minors, as well as for students in the integrated science program (to fulfill courses related to conservation agriculture). I have tried to structure the course to provide an introduction to systems thinking and group work, with an emphasis on principles of crop management. Further, in spring 2019 I planned for syllabus learning outcomes to coincide with the Departmental curriculum committee's broader learning outcomes for the majors such as working with data, synthesizing current information, and working professionally with systems (Table 1).

Table 1: Major assignments in Agronomy 204 and their planned learning outcomes for the course and the Agronomy and Horticulture Department

Assignment	Syllabus student learning outcome tracked to this activity	Departmental student learning outcomes
Summarizing a peer-reviewed article related to crop management in a screencast video	• Synthesize information from peer-reviewed articles to understand the steps in the scientific process and how new scientific knowledge is generated about agriculture	• Working with data: Analyze quantitative and qualitative information, including that in graphical forms, to draw appropriate inferences. Communicate plant and soil knowledge and management action using evidence-based and technically sound oral, written, and multimedia communications. • Capitalize on current information and demonstrate effective communication: Identify, evaluate, synthesize, and interpret evidence-based information to solve complex plant and soil system problems.
Introduction to Farming Simulation (APSIM) – Creating a simulation or analyzing results of a crop management simulation of the students choice	• Utilize the farming simulator tool *APSIM* to aid in crop management decision-making, to develop hypotheses around management changes and predict subsequent outcomes • Differentiate between management considerations in various cropping systems and evaluate the	• Work professionally with systems: Anticipate future challenges in plant and soil systems, and develop and test innovative solutions to those challenges. • Capitalize on current information and demonstrate effective communication: Identify, evaluate, synthesize, and interpret evidence-based information to

	underlying processes that lead to agronomic and environmental outcomes	solve complex plant and soil system problems.
Designing and planting (in greenhouse and field) a cover crop species mix optimized for diversity and biomass	• Differentiate between management considerations in various cropping systems and evaluate the underlying processes that lead to agronomic and environmental outcomes • Collect, organize and analyze experimental data from agronomic experiments • Describe the basic management (i.e. responsible input use, cultural practices) and natural resource considerations (i.e. temperature, rainfall sunlight, soil) necessary for agronomic production	• Capitalize on current information and demonstrate effective communication: Identify, evaluate, synthesize, and interpret evidence-based information to solve complex plant and soil system problems.

Overview of farming simulation assignment and activities

An important approach to meeting multiple learning outcomes was to have students work with the Agricultural Production Systems sIMulator (APSIM) platform. The Agricultural Production Systems sIMulator (APSIM) is internationally recognized as a highly advanced simulator of agricultural systems. It was developed over two decades ago and is still maintained by a team of scientists at the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia. It is a freely available computer program that contains a suite of modules which enable the simulation of systems that cover a range of plant, animal, soil, climate and management interactions. Although there is some "learning curve" associated with using the program, it has various components or modules depicted in its user interface with menus that can be utilized in a "plug and play" type fashion, as compared to a model that is strictly code/script based (see screenshot in Figure 2). From a pedagogical standpoint, the power of the platform comes from its ability to represent a range of different possible crop and soil management decisions and to evaluate what happens when various aspects of the environment or management change. This can be done efficiently with the platform as compared to expensive and time consuming field experiments.

The syllabus described the assignment and directions were provided to students to encourage them to begin downloading the software on the first day of class (Appendix A). Students were expected either to download the software or to utilize departmental computers that had the software. Five course periods were dedicated to work through in-class activities in small groups. Introductory materials (approximately four pages) that I created to orient students to the software were assigned reading for the first course period in week seven of the semester. In addition, there were a series of screencasts available to students on Canvas that I recorded as introductions to the user interface, basic functionality of the tool as well as more information about the assignments. There were also "how to" documents online that described for students how to create/edit a simulation and how to create their own soil profiles if they desired to do so (this was not required as all files required to run the program were provided).

After the first two course periods and in week seven of the semester, part one of the assignment was due, which asked students to outline the "experiment" that they would execute with the platform. In part one, students were asked to describe the various aspects of management (such as seeding rates, crop rotations,

or water application) of interest to them and to develop a hypothesis about what might occur. I graded all of these assignments and provided feedback to students where I felt more direction was needed. I encouraged many students at this stage to visit either with myself or the postdoctoral research fellow (Dr. Nilovna Chatterjee) working in my research group who was supporting this module. The second part of the assignment, which was due after all in-class demonstrations were complete and in week 14 of the semester, asked students to run their experiments, analyze results and describe outcomes. Dr. Chatterjee and I both offered additional office hours to accommodate student questions as we anticipated that support would be needed. The assignment prompt for parts one and two of the assignment is provided in Appendix B and the grading rubric is provided in Appendix C.

Students were encouraged repeatedly to start the assignment well in advance of when it was due in order to have ample time to troubleshoot. I did hear from a number of students (addressed in the following sections) with targeted questions about the computer program and their assignment. However, I still sensed that a number of students were struggling to complete the assignment. As a result, about two days before the assignment was due, I chose to offer an alternative for students, in which I provided the information and results from a pre-set up experiment that we had previously discussed in class and allowed students to answer the questions based on these pre-established results. Students could select this option if they were having trouble with their own simulations, but they were made aware that they could not receive full points for utilizing this option because it would not allow them to have explored their own unique hypothesis and experiment.

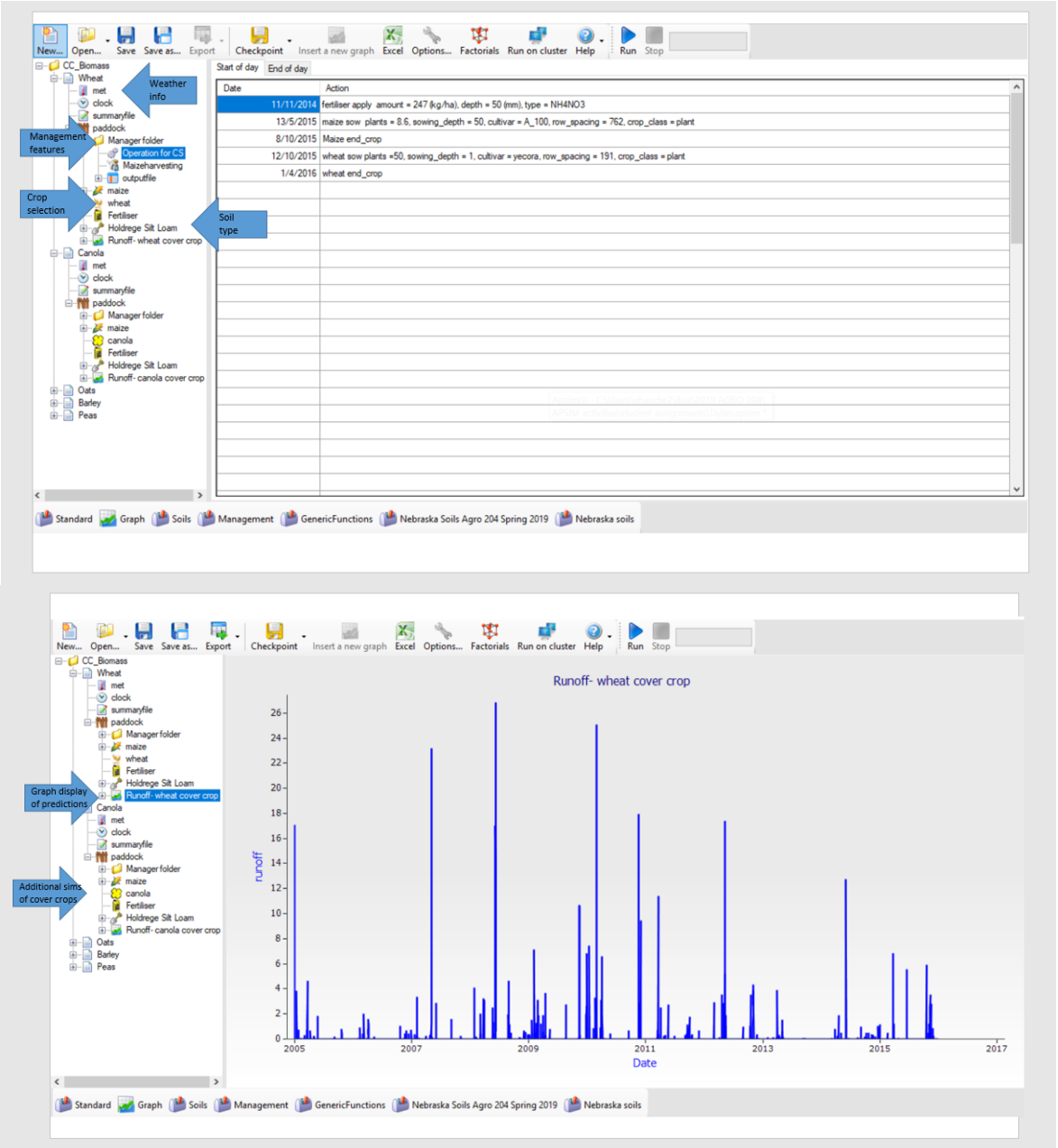

Figure 2. Screenshot from an exceptional student assignment displaying the APSIM platform user interface's modular features within the "simulation tree" such as the crop modules (displayed above as maize, wheat and canola), soil type (Holdrege silt loam), management features (top panel above displaying the planting dates, planting rates, row spacing and fertilizer rates). The below panel displays the graphical representation of the predictions for runoff produced by the tool. In this assignment, the student explored how different cover crop species following corn impacted water runoff

Assessment of student learning

This section of the portfolio will describe the evidence that I collected and analyzed to document how well students met my desired learning goals as well as if they adequately learned some of the central course ideas and departmental goals. For this assessment, I include results both from the student assignment, analyzed quantitatively and qualitatively, as well as results from a pre- and post- assignment online survey that was created in collaboration with my colleague Dr. Carol Speth, Education Assessment Specialist in the Department of Agronomy and Horticulture.

Quantitative summary of student performance

The primary quantitative analysis was conducted using the R Studio platform with one-way ANOVA tests and differences between groups analyzed using Tukey HSD pairwise comparisons, as well as histograms to assess distributions of grade performance. Eighty-one out of 103 students in the course gave permission to use their assignment information and grades in this portfolio. Briefly, most students performed well in part 1 of the assignment, receiving a score of 93.2% which represented an A in the course. As previously noted, I left detailed comments for students where it was clear more direction was needed to move forward on the second part of the assignment.

The main emphasis of my analysis is on part two of the assignment. In part two, the average score was an 86.8% (representing a B in this course) with a standard deviation of 11.5%. There were 46 students earning scores of an A (>90%, with 12 students 2earning a 100% score), 9 students earning scores of a B (80-89%), 16 students earning a scores of C (70-79%) and 10 earning a score of D or F (<69%) (Figure 3). One of the most important determinants of the final score were students who completed their own simulation rather than the alternate assignment, because the alternate assignment did not provide an opportunity to utilize original hypothesis. Seventy percent (n=57 students) of students completed their own simulations for the assignment while 30% of students (n=24 students) utilized the alternate assignment, and there were significant differences between these grades. Those who completed the assignment using an original simulation and hypothesis received an average of an A (mean of 92.3, standard deviation of 7.6), while those who completed the alternate assignment using a previous simulation received an average score of a C (mean of 74.6, standard deviation of 9.5). There were not statistically significant differences found between majors for performance as illustrated by a statistical analysis and can be seen by a histogram of the distribution of grades (Figure 3). Further, there was not a very strong relationship between the final grade and grade on this assignment (Figure 4), demonstrating that students who received an A overall in the class could still have received a B or C on this assignment, or vice versa, that students receiving lesser overall scores in the course may have performed well on this assignment. There was also not a clear pattern observed where students from one major performed consistently well (or poorly) in this farming simulation assignment or the course overall.

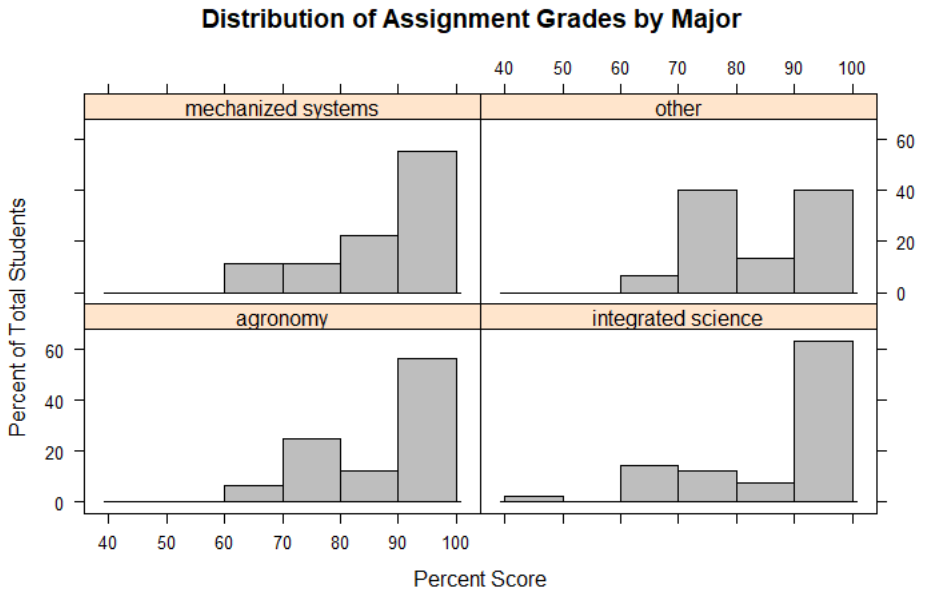

Figure 3. Farming simulation assignment grade distributions broken out by student major. The three largest majors represented in the course and in this subset of the students were agronomy (16), integrated science (41) and mechanized systems (9). Other majors (15) included agricultural business, agricultural education, meteorology, and plant science.

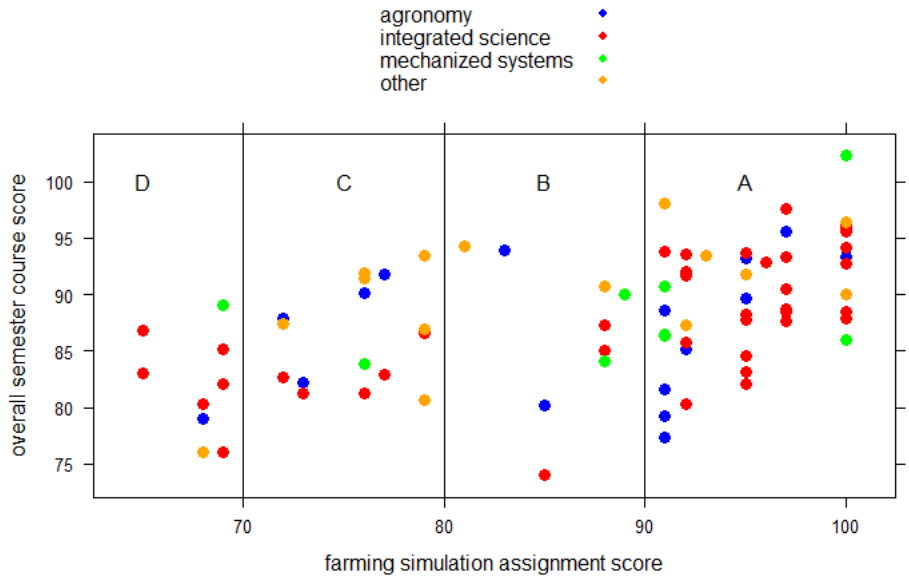

Figure 4. Regression plot of farming simulation assignment score (x axis) and overall semester score (y axis) grouped by student major.

Qualitative analysis

The assignments from the students who gave permission were analyzed using the QDA Miner Lite Platform using an iterative coding structure with a primary emphasis on 1) the crop and soil related processes (i.e. crop growth and photosynthesis, nutrient cycling, or water use) that students explored in their simulations; 2) what students identified that their learned from the assignment (i.e. how to use the

software, awareness of simulation platforms, data analysis, hypothesis development and experimental design); and 3) how students could envision using this type of platform in the future (i.e. conducting experiments, recommending management decisions, use on their own farms). Further details of the coding structure are presented in the below sections. I was the only person analyzing this data, so no intercoder reliability could be assessed. However, a number of direct quotes are presented in the following sections to demonstrate transparency and add a detailed look at student work.

Crop and soil related processes described by students

Assignments were coded for one of three possible crop and soil related processes – crop growth/photosynthesis, soil processes/nutrient cycling or water use - based on the predominant idea that students were describing from their simulation. Seventy-four of 81 students (representing 91%) were coded for one of these three topics, representing the majority of students who were able to identify a relationship between something that was changed in their simulation and a subsequent predicted outcome. Students' ability to explain a process underpinning crop management was a major goal of this assignment. From the remaining seven students who did not adequately describe a relevant process, all but one were those who completed the alternate assignment. Of those coded, 46% described a process related to crop growth/photosynthesis, 39% described some aspect of water such as transpiration or irrigation, and 16% described some aspect of soil outcomes or nutrient cycling such as nitrate or phosphorus changes and soil structure. It is recognized that all of these processes are inter-related, but I was interested to see which aspects of crop management outcomes students might gravitate toward understanding. These choices would have also been constrained by what examples were used in class so are not necessarily reflective of all possible outcomes that students could have explored based on the APSIM platform's capabilities.

Learning described by students

In response to the assignment prompt "Explain in at least two sentences the most important thing(s) that you learned from this experiment" responses were coded based on the following themes: Learning how to use the software; Awareness of the platform and similar farming simulation programs; Developing and testing a hypothesis; Explaining how changing crop management or environment (soil/climate) changes outcomes; Ability to analyze data. I coded as many themes for each student as I felt fit into their answer to this question (Figure 5). The highest number of responses to this question were in regards to what students learned about the impact of management or environment (such as soil type or climate) changes on agronomic or environmental outcomes (such as yield, crop transpiration, runoff, leaf area or soil nitrate; n=65). A number of students were able to point to learning about how to operate the APSIM platform (n=17) as well as awareness of simulation platforms (n=17). A few students specifically mentioned that they gained knowledge about how to analyze data (n=6) and developing hypotheses (n=4). Select quotes are presented in Table 2. Based on student simulations, they reported how they discovered a range of new potential management understandings, from the impact of planting dates, soil types, climate change and crop rotations on various agronomic outcomes such as crop yield or nutrient loss.

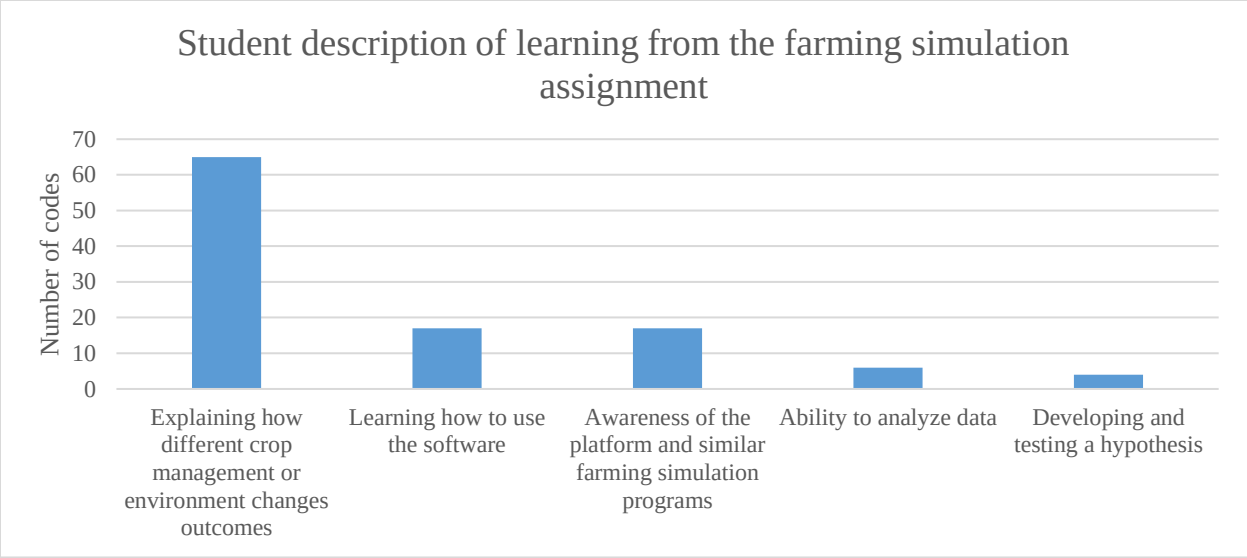

Figure 5. Number of responses coded for various themes as students described the most important thing(s) that they learned from the experiment.

Table 2: Select student answers to the prompt: "Explain in at least two sentences the most important thing(s) that you learned from this experiment"

Theme	Student quote
Impact of crop management changes	There are many things that can factor into how a cropping system functions like, temperature, precipitation, fertilization, soil type and hybrid/variety. It is hard to set up an experiment that keeps all those variables constant except the one you are testing due to the nature of farming systems.
	The most important thing that I learned is the importance of climate change. If I could've increased the CO2 concentration, the effects would've even been worse. This simulation shows that corn has a negative effect from increasing temperatures due to climate change.
	In this experiment, I learned that growing crops earlier in Rwanda rises the chances of increasing the maize yield. The management practices can increase the yield, but the earlier grown crops still yield higher.
	I learned that this land that I created the soil profile for could deliver a much more consistent yield if we were to implement an irrigation system on it. It would not only perform better in the bad years, but also better in the good years. However, further cost inspection should be done before making a decision. Also, I learned that irrigation and rainfall timing are more important than the cumulative seasonal amount of water received.
	The most important things I learned from doing this simulation are that wheat deserves to be looked at as a possibility for our cropping system. Adding wheat into our cropping system could potentially help us raise our corn and soybean yields in the years that they are planted in the rotation.
Awareness of software	Farming simulations are great for taking a lot of data and putting it all together to show patterns and averages in plots that would be hard to see in the field. This is helpful if you wanted to see a certain area in your field that is not producing as well as the rest of the field. You could record averages of nutrient levels, slope, erosion, soil type, and other factors to see why that area was yielding less.
	Tools such as APSIM are very helpful (although hard to first figure out) in determining what management practices may be best for our area.

	I learned that you can test and compare a lot of different things with the simulation that otherwise would be extremely hard to compare. The results from the simulations may not always be spot on with the yield but the general trends that it shows are usually accurate.
Hypothesis development and data analysis	The first thing I learned from this experiment is that not always your hypothesis is true.
	I learned to make assumptions using management practices in a given environment by considering different variables to make hypothesis and carry out simulations to see if they can run.
	Also, this experiment taught me how to set a hypothesis, prove it, and report what I saw in the activity.
	I learned how evaluate and interpret APSIM data and graphs and how simulate farm field which will help me in farming management.

Future use of related platforms

In response to the assignment prompt "Explain how you could envision using decision-support tools such as the farming simulation platform APSIM in your future careers in agriculture" responses were coded based on a few key themes: describing use for recommending crop management decisions, creating new experiments using the tool, or using the tool as part of their own operation. For this category, I also coded as many themes for each student as I felt fit into their answer to this question (Figure 6). Of those answers coded, 58% (n=49 students) referred to using the tool to make recommendations about crop management, 25% referred to possibly using the tool on their own operation (n=21 students) and 17% referred to using the tool for their own experiments. Select student quotes are presented in Table 3. Many recognized that having a predictive tool could be beneficial in decision-making especially before testing new crops or different management, recognizing that the tool can help set up experiments, and can reduce some of the "guessing" or "ifs" of trying new strategies. Students recognized that using a simulation platform to test different management options could ultimately save producers money. Further, many students recognized the potential policy recommendations that could be created as a result of using the platform. Some even noted that having software capabilities is a benefit to future potential employers.

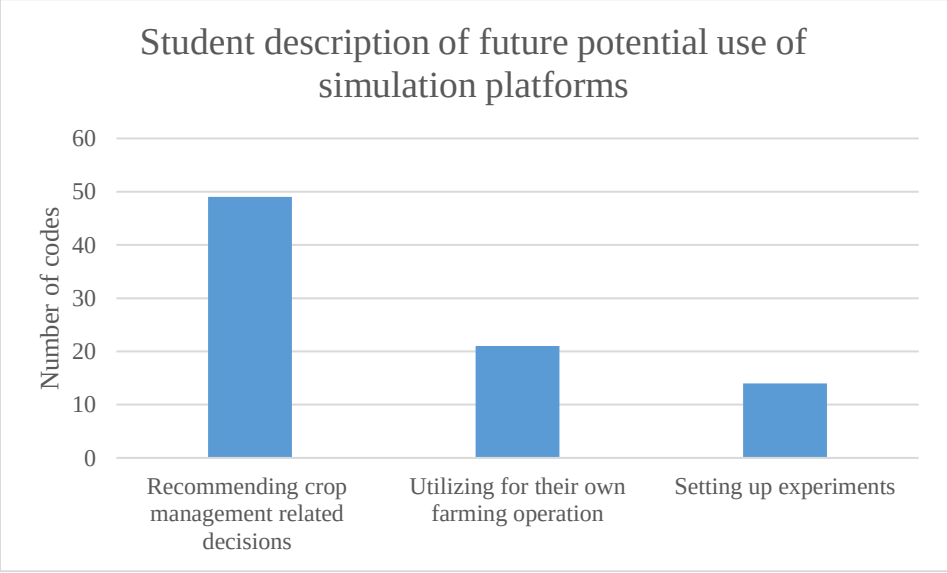

Figure 6. Number of responses coded for various themes as students described their potential future use of simulation platforms.

Table 3. Select student answers to the prompt: "Explain how you could envision using decision-support tools such as the farming simulation platform APSIM in your future careers in agriculture"

Theme	Student quote
Recommending crop management related decisions	As this technology gets better and more accurate you would essentially be able to simulate your whole year before you even start a tractor. For example, you could run it to see how different irrigation rates effect yield or biomass.
	I believe for people in charge of developing new policies or technologies in agriculture can use decision-support tools such as the farming simulation to test new policies or technologies before they are applied on a bigger scale. For instance, figuring out what is the appropriate seeding rate or row spacing.
	As an educated farmer, I sure will need to make intensive study of the soil and crop decision management before further action. Models like APSIM would be important to me to assess and predict the properties of the field in order to know what to add or reduce, know suitable management to maximize the yield and quality.
	I am certain that most farmers in Rwanda do not know when the best date to sow is. I myself did not know that there was a simulation for something like this. I think that this simulation will help me to compare the yields of previous yields back home to determine when the best time to plant is. This will allow farmers to have a more income.
	I think these are so beneficial to help students understand all the components that you can adjust to help grow and develop your crops. However, as a potential teacher this is great to understand to give students who are very passionate about agronomy work, precision ag, and other advances in farming.
	I could envision using to help make decisions like I was trying to make with this simulation. It is hard to know the benefits of an investment. But, if you can get a modeling software like APSIM and run a few simulations, you can get a much more educated guess than an off-hand estimate. This software could help with economic decisions and future profitability estimates as well. So, I really see the benefit of this software as aiding with investment decisions about the feasibility of projects
	I believe Farming simulation platform APSIM is one of the important tools that farmers, researchers and students should use to make some farming decisions. Specifically, for me as a student, I intend to use these this platform to study different variable with their output so that I can give agronomic decision to Rwanda farmers that do not know how to use it. These tools help you predict what might happen based on the previous resources which might reduce some costs and give high interests.
	We could use the tool to help show farmers that growing a specific crop in the area might not be as beneficial as thought. Even though there would have to be data from which the program runs on coming from growing seasons it could still help farmers move away from the initial idea of growing a new crop.
Utilizing for their own farm operations	I found this tool to be very interesting. In the future I could see myself using APSIM to look at how different soil types on land I own effect the amount of nitrogen I would have to apply and look at how different application timings would affect yield. I could also use it to look at the potential benefits to planting different crops.
	I hope to be able to return to our family farm and I think being able to use software's like this is very important when trying to make important management decisions. I also think that APSIM really helps people sit down and consider all of the different aspects of what might go into farming and how different variables have different impacts. Also, this might get farmers to realize that some variables can be effectively controlled under proper management decisions. Also, knowing how to use different

	software looks really good to potential employers and it is something they really appreciate job candidates knowing.
	Growing up on a farm where my dad didn't have any tools like APSIM to help him predict or get recommendations, has helped me value information and such resources more. As I plan on keeping my dad's farm for research purposes and become a consultant in my area, I believe decision support tools like APSIM will help me work efficiently and effectively while recommending other farmers on some management practices that suit their land.
	I would use a platform like this to see what I could improve on from year to year. I will use a platform like this to test different theories I have to improve my farm without actually doing them on your field and wasting money on experimenting. I would also use it depending on what you think the growing season will be like, whether you think it will be a dry year or wet year, and run a simulation based on previous years that have the same weather, to see how your crops will be affected. This can help my farm with saving money and help with management decisions. Platforms like this are nice to use because you can see how your yields can be affected depending on what practices you are using.
	I am passionate about food and water security in Sub-Saharan Africa where technology in agriculture is still less developed. Monitoring simple management practices such as row spacing, planting density, and planting date could make a great impact on the crop production in this region without incorporating more expensive inputs to farmers. I find the simulation models such as APSIM, as important tools that can help me try the ideal recommendations on management practices to predict their effectiveness in real world before reaching out to farmers.
Setting up and refining experiments	When making decisions, they often have to be completed within a very timely manner so in most situations, it is not possible to go set up a field experiment, monitor the field experiment, and then repeat the field experiment to confirm the same results. Tools like APSIM have made it very possible to overcome situations that involving guessing or copying something that other farmers have done. These tools use a large amount of data to predict outcomes for potential crop yields, crop rotations, almost any other variable when growing crops. I could see myself using a tool similar to APSIM to analyze crop and soil health so I can help farmers grow cover crops and implement sustainable solutions to increase their soil health.
	A way this could be used in the future it to help farmers have an idea of what could happen. This can be of much benefit for farmer just starting out or even those who are wanting to look into production of something they have never grown before. This APSIM program in the whole grand scheme of things answers the "ifs" and questions for farmers who want data.

Pre- and post-module survey results

The pre- and post-module survey, administered the third week of the semester and the fifteenth and final week of the semester, respectively, asked students to quantify how confident they felt about several skills related to the farming simulation activity, including hypothesis development and data analysis. The exact survey prompt read: "*How confident do you feel in the following knowledge and skill areas? Answer with a percentage from 0% to 100%, but leave off the percent sign. For example, if you 95% confident, enter 95, If you are 50% confident, enter 50*." As depicted in Figure 7, mean student confidence in all aspects increased by 13-15 percentage points from the pre-survey to the post-survey.

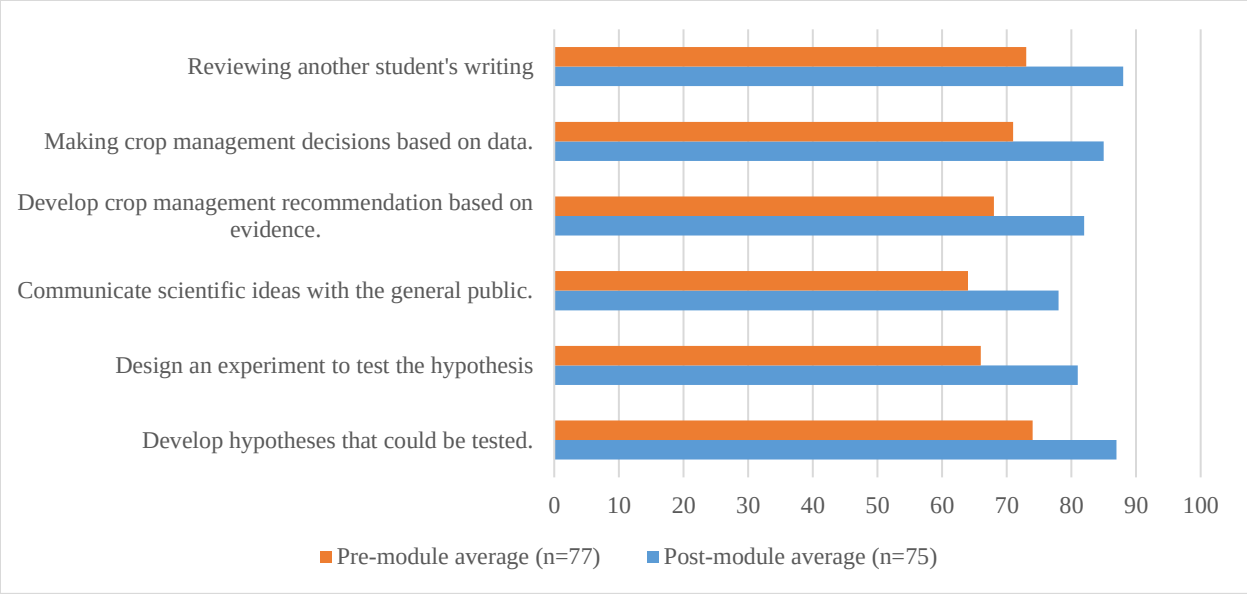

Figure 7. Student reported confidence levels for various skills and knowledge included in Agro 204, from the survey administered pre- and post- farming simulation module

Further, the post-survey asked for student agreement or disagreement (with a five point likert scale) with three specific questions related to the simulation activities as displayed in Table 4. Sixty-seven percent of students agreed with the statement that "The simulations helped me understand the interaction of controllable and uncontrollable factors that affect yield." Fifty-five percent of students agreed with the statement that "We received enough guidance before the simulations to get started right away" and 49% agreed that the "The simulations were a good use of class time."

Table 4. Results from the farming simulation specific questions on the post-module online survey. Seventy-five students responded to all of the below questions

Survey question	% strongly agree	% agree	% neither agree nor disagree	% disagree	% strongly disagree
The simulations were a good use of class time.	16.00	33.33	28.00	14.67	8.00
We received enough guidance before the simulations to get started right away	18.67	36.00	26.67	14.67	4.00
The simulations helped me understand the interaction of controllable and uncontrollable factors that affect yield.	18.67	48.00	21.33	9.33	2.67

Finally, in the post-survey students were asked the open ended question "Please give an example of something valuable you learned in this Resource Efficient Crop Management course." Seventy-two responses were received for this question and even though students could identify any aspect of the semester-long course, 13 responses referred to learning the simulation platform as valuable, another 10 referred to data analysis and hypothesis development, and another 7 referred to more familiarity with peer-reviewed research, extension publications or other publicly available resources. Select quotes from student responses to this question on the post-survey are in Table 5.

Table 5. Select student quotes from the post-farming simulation survey, in response to the prompt: "Please give an example of something valuable you learned in this Resource Efficient Crop Management course."

Student quote
I learned how to use the APSIM and how to relate different data from articles toward the decision making
The farm simulator was the most interesting thing we worked on, I can see using technology like this the future to benefit farmers.
I learned how to use the APSIM tool I learned more about cover crops their different families and the uses
APSIM simulation was an interesting way to approach technology.
The benefit of cover crops through the paper that I peer-reviewed and made a presentation over. Also, the benefit of cover crops was discussed thoroughly in class.
Agricultural available information and reports are very important when it comes to making an agricultural management practice decision.
How to use different University Extension papers and modules
Learning how to use the APSIM software will prove very valuable to have the ability to test certain input variables such as row spacing on our farm.
The importance of how and why simulations (new technologies) can greatly improve resource efficient crop management. Being able to find/see problems that we otherwise wouldn't be able to find in a field. An example of this is water management in specific areas of a field.
using prediction software to help in decision making
Using APSIM was definitely valuable! We learned how to estimate yields in different conditions. This is valuable because it gives a framer some idea of what it would be like if they used certain management practices.
While the simulations were hard to do because it is a difficult software to use, I think it is valuable to have exposure to it. When you apply for jobs, employers really appreciate when a potential employee has experience with softwares

Conclusion: reflection on planned course improvements

Farming simulation module and assignments

As expected, there was a range in student performance on this assignment. Some performed exceptionally and created very sophisticated simulations and analyses, from representing climate change on their own farms to multiple cover crop species that they might utilize or recommend in the future. I was extremely pleased with the work of many students in this assignment, yet simultaneously disappointed with the clear lack of effort from others. In spite of additional office hours, online screencasts and materials, as well as significant course time (five 80-minute lecture periods) dedicated to using the simulation platform, I recognize that many students struggled with the assignment and this requires a critical reflection on how to improve this assignment and related activities in the future. When students came to office hours for feedback, I repeatedly heard that they "did not know where to start". I believe that the largest barrier for many students fully participating in this assignment was their ability to operate the software, as illustrated by some of the comments in the assignment presented in Appendix D. This is unfortunate because what was more important as a learning outcome was the students' ability to identify processes related to predicted outcomes and to gain experience working with data. The majority of students who completed the alternative assignment were still able to meet the major learning outcomes of the assignment, as illustrated by the qualitative analysis. There were also a number of students also did not earn points because they failed to follow directions and to incorporate external resources such as extension publications or peer-reviewed articles. This is something that I will need to more clearly articulate in class.

I kept detailed records of the number of students who visited during office hours or corresponded via email about the assignment with myself, the postdoctoral research fellow supporting this module or our undergraduate teaching assistants for the course. We estimate that at least 26 students sought additional help on their assignment; this is a reasonably high number (approximately one-quarter of the class) that, in my opinion, made a great effort to complete the assignment. I further estimate that at least eleven students (out of 103 total, or 11%) explicitly noted in their assignment that they set up their simulation with the intention of it representing their own farming operation. I am very pleased with this, in addition to the number of additional students who commented in the assignment that they could see this benefitting their operation in the future. While I was somewhat disappointed with the lack of effort my some students, I do recognize that the weather may have played a role in overall student performance this semester. We had one class cancelled due to weather (2/20) - a period initially scheduled for the farming simulation but that was later made up in the semester. There were a number of students who missed classes due to snow or other inclement conditions. Winter 2019 was one of the colder wetter winters in the state in addition to the historic flooding in March.

Peer-reviewed article and cover crop challenge assignments

In general, I was very pleased with student performance in the other two larger assignments administered during the semester. I was particularly pleased with students' ability to synthesize information in the peer reviewed article assignment. The average score on the screencast video of the peer reviewed article was an 89.9%. While student groups also performed well on the cover crop challenge related assignments (89.9 and 89.1 for parts one and two respectively), there was some confusion about which students were meant to work in which groups given the multiple steps in that assignment, and this led to lower grades and frustrations from students. I believe that setting the course up with more specific units where one of the three larger assignments is due at the end will dramatically reduce some of the confusion that existed this semester. Next year, I plan to make the first unit focused on natural resources and data that will culminate in the peer-reviewed article assignment, the second unit focused on crop production and

simulations that will culminate in the farming simulation activity, and the first unit focused on integrated systems which will culminate in the cover crop challenge assignment.

Plans for improvement

There were a number of students who left detailed comments about their struggles with this assignment (see Appendix D for select quotes from students). Further, the post-module survey results (Table 4) found that 27% of students neither agreed nor disagreed and another 19% disagreed with the statement that "We received enough guidance before the simulations to get started right away." Another 23% disagreed that the statements were a good use of class time. These results suggest that the farming simulation activities may have pushed many students who are less confident in their technology skills out of their comfort zones. However, I believe there are a number of ways to improve and that it is worthwhile to do so given that so many students performed successfully and learned a valuable new skill through the activities. This semester I did not require students to have the software on their computers because a select number of departmental laptops with the software were made available for groups to work with during in-class activities or to borrow after class for assignments. However, I do believe that some students did not take full advantage of the time in class to learn how to use the program, especially if they were not engaged directly with the software on their computers. Next year, I intend to require students to have the software. Another important change is that I plan to include all of the farming simulation in-class activities back-to-back lecture periods rather than dispersing through the semester. I intend to complete the farming simulation activities in a two to three week period in the future. I may also make the assignment more directly tied to data analysis and less to the students' ability to operate multiple aspects of the software. Another option is to include a shorter assignment first with more open-ended assignment where students first gain practice altering a simulation and extrapolating results. I intend to dedicate one of the in-class periods with the program (as well as a screencast video) to showing students how to create a simulation from scratch. A number of students commented in their assignment that this would have been beneficial, as opposed to only working with pre-established simulations (Appendix D). I may also require that students come to one-on-one consultation to discuss their simulations and any issues that they are encountering. Finally, I plan to improve the materials on Canvas related to the farming simulation software to reduce confusion about which screencasts and documents can help guide students depending on what questions arise. I recognize that this is a sophisticated assignment for a 200-level course, but believe that with improved execution it will be even more successful in the future.

Appendix A

Agronomy 204 Course Syllabus

Agronomy 204
Resource Efficient Crop Management
Spring 2019
Updated 4.2.19 (changes highlighted)

Instructor: Dr. Andrea Basche
Office: 279G Plant Sciences
Phone: (402) 472-6413
email: abasche2@unl.edu
Section 1: MW 9:00am-10:20am; Gooding Center, Plant Sciences
Section 2: MW 1:00pm-2:20pm; Gooding Center, Plant Sciences
Office hours: Wednesdays 10:30am-12:00pm; *or by appointment*

Teaching Assistants

Samantha Teten — Office hours: Tuesdays 9am-10am
Email: sam.teten@gmail.com — Location: Plant Sciences 271
Jared Muhlbach — Office hours: Mondays 2:30pm-3:30pm
Email: jmuhlbach24@gmail.com — Location: Plant Sciences 271
Evan Hansmeier — Office hours: Thursdays 2pm-3pm
Email: eshansmeier@gmail.com — Location: Plant Sciences 279A
Any updates to regular office hours will be noted on Canvas and in class

About the course

The landscape of agriculture is constantly changing. In 2019, producers are under competing demands to sustain their livelihoods, maintain finite soil and water resources for the future, and produce for a shifting consumer marketplace. The development and evaluation of crop management practices requires an ability to integrate the principles from a range of disciplines such as crop and soil science, plant breeding, climatology and integrated pest management. This is essential to make the most efficient use of natural resources such as solar radiation, water, soil nutrients, heat, carbon dioxide, as well as other inputs utilized for field crop management.

Learning outcomes

As soon to be agricultural and natural resource professionals, you will be tasked with solving complex problems where multiple priorities and considerations will need to be evaluated.
To better prepare you for such challenges, in this course you learn to:

- Describe the basic management (i.e. responsible input use, cultural practices) and natural resource considerations (i.e. temperature, rainfall sunlight, soil) necessary for agronomic production
- Identify how to find, and subsequently utilize publicly available data and resources relevant for agricultural decision-making
- Collect, organize and analyze experimental data from agronomic experiments
- Differentiate between management considerations in various cropping systems and evaluate the underlying processes that lead to agronomic and environmental outcomes
- Synthesize information from peer-reviewed articles to understand the steps in the scientific process and how new scientific knowledge is generated about agriculture

- Utilize the farming simulator tool *APSIM* to aid in crop management decision-making, to develop hypotheses around management changes and predict subsequent outcomes

In this class, you will have the opportunity to practice many "employability" skills such as effective note-taking, communicating complex scientific material, providing constructive feedback to peers, identifying and organizing key information in lectures, and using various computer technologies (such as Microsoft Excel, VidGrid, APSIM). Regardless of your future professions, I expect that these will be transferrable skills to many different tasks and employment sectors throughout your careers.

Grading

Assignment	**Due dates***	**Points**
Introductory survey	Wednesday, January 9	10
Quizzes	Weekly on Wednesdays, lowest score dropped 11 total (10 counting for grades), 12.5 points each	125
Midterm	Wednesday, March 13	100
Cover Crop Challenge Activity	Part 1 – Planting rate activity Wednesday, March 6	50
	Part 2 – Cover crop challenge activity Wednesday, April 24	100
Analysis of peer reviewed article activity	Part 1 – topic selection Wednesday, February 13	10
	Part 2 – video summary Wednesday, March 27	65
	Part 3 – responses to peer feedback Wednesday, April 3	25
Farming simulation activities	Part 1 – topic, hypothesis & proposal Wednesday, February 20	25
	Part 2 – final report Wednesday, April 10	75
Final	Section 1: Tuesday, April 30 7:30am-9:30am Section 2: Wednesday, May 1 3:30pm-5:30pm	150
Total **Note: field activity assignment removed and two quizzes removed**		735

***Subject to change**

All assignments are due at the time class starts: 9am for Section 1 & 1pm for Section 2

Grading system

Grade	**Percentage**	**Grade**	**Percentage**
A+	98.0 – 100.0%	**C+**	78.0 – 79.9%
A	92.0 – 97.9%	**C**	72.0 – 77.9%
A-	90.0 – 91.9%	**C-**	70.0 – 71.9%
B+	88.0 – 89.9%	**D+**	68.0 – 69.9%
B	82.0 – 87.9%	**D**	62.0 – 67.9%
B-	80.0 – 81.9%	**D-**	60.0 – 61.9%
		F	59.9% or less

Participation
As in other aspects of life, you will get out of this course what you put into it! This means that your participation and engagement is essential. In addition, YOU bring a tremendous amount of life experience and practical knowledge into the classroom. I want you to share that with me and other students and you will be given ample opportunity to do so through in-class activities and discussions. Attendance will not be taken in class, but students in Agro 204 in Spring 2018 with greater attendance tended to receive higher grades. Arriving late to class on rare occasion will be excused but I request that you make every effort to arrive on time so as not to distract your classmates or to miss important content at the beginning of class, including weekly quizzes on Wednesdays. While every session that we meet is important, the schedule notes several dates (for example: outdoor activities, greenhouse activities, peer review activity on 3/27) where attendance must be prioritized. I understand that personal situations arise, but please plan to notify me in advance if you cannot be in class.

Quizzes and Exams
There will be a number of quizzes throughout the semester (see course schedule) that *can only be taken by a student when they are in class*. Quiz questions will cover content discussed in prior classes and in assigned readings. In some instances, if students are ill or have previously arranged with me to miss class for extracurricular activities, make-up quizzes *may* be allowed. The lowest quiz score will be dropped at the end of the semester. There will be a Midterm Exam on March 13th and a Final Exam during Finals week that also *cannot* be rescheduled. However, in the rare circumstance that there is a legitimate extracurricular activity, illness, or other unforeseen situation that cannot be avoided, I *may* allow for rescheduled exams. In general, please reach out to me far in advance (preferably at least two weeks in advance) about any conflicts that you may have with any quizzes, exams or assignments.

Course textbook and assigned readings
The textbook "Introduction to Agronomy: Food, Crops, and Environment (2nd Edition)" by Craig C. Sheaffer & Kristine M. Moncada will be used and readings will be made available on Canvas, and a reserve copy will be available at C.Y. Thompson Library on East Campus. Additionally, a number of other resources will be made available on Canvas (see below reading schedule) including University of Nebraska Extension NebGuides, Government materials and other University Extension documents.

Assignment due dates
All assignments will be due the day that is listed on the syllabus, Wednesdays, at the time that class begins: 9am for Section 1 and 1pm for Section 2. Any schedule changes will be noted in Canvas and/or in class messages. Late assignments will have 10% of the total points deducted for every day that they are turned in late. All assignments should be turned via Canvas unless otherwise noted.

Farming simulation "APSIM" activities
Digital tools to support production and sustainability are prevalent in the current agricultural landscape, and very likely to be a part of your future work in the field. We will be working with a farming simulation platform (Agricultural Production Systems sIMulator or "APSIM") to

further understand the impact of management decisions on production and environmental outcomes. You will be expected either to download the software or to utilize departmental computers that have the software. The program, unfortunately, does not run on Mac computers, unless you have the Parallels for Mac software (which is available for purchase from Huskertech at the City Campus Union for ~$40), or if your Mac hard drive is "partitioned" to run windows software. Detailed instructions and in class activities will support your successful download and basic functionality of the program. We will work through in-class activities in groups (ideally, all members of the group will have a laptop to run the program) in several sessions. You will work individually to design an "experiment" where you will manipulate various aspects of management (such as seeding rates, crop rotations, or water application) of interest. You will develop a hypothesis about what will occur with these manipulations and analyze the results. Part 1 of the activity will ask you to outline your experiment and in Part 2 you will run your experiment, analyze results, and describe outcomes. Additional information will be made available on Canvas by the end of January.

Peer review activity
With the vast information resources available at our fingertips, it is increasingly important to be able to find and utilize credible resources. To help you hone your skills in understanding where agronomic recommendations and information come from, you will have the opportunity to select a peer-reviewed scientific research article related to a topic(s) covered in Agro 204 of your interest. Over a series of assignments you will summarize the main findings of the research and respond to questions from your peers. Part 1 of the assignment will ask you to select the article, describe why you chose the article/topic, and begin reading. Part 2 of the assignment will ask you to record a short presentation (5 minutes) summarizing the article's results so that your peers can understand it. For this part of the activity, you will need to use the VidGrid platform, available for free through UNL, to record a screencast video of your article summary. We will have time in class to watch the videos of others, to provide feedback and ask follow up questions, on 3/27. Part 3 of the assignment will ask you to respond to these questions and feedback. Additional information will be made available on Canvas by mid-January.

Cover crop challenge
Cover crops are increasingly being studied by agricultural scientists and utilized by producers to improve overall productivity and to address sustainability concerns such as soil degradation, water pollution, and herbicide resistant weeds. To introduce you to practical aspects of cover crop management, you will collaborate with 1-2 classmates to design the most efficient cover crop mixture, using both economic and agronomic metrics. These activities will encompass several course periods. The first activity includes evaluating different seeding rates for growth and ground cover, to introduce you to different cover crop species. The second activity includes both a greenhouse and field experiment. Groups will select seeding rates for different cover crop species that will grow both outside (East Campus field experiments) and in the teaching greenhouse behind Plant Sciences and Keim Halls. Groups will take responsibility for maintaining the growth of their cover crop experiment in the greenhouse over several weeks. We will plant our experiments in early March and measure cover crop growth in mid-April. The groups that design the most efficient cover crop mixes will receive extra credit (10 points) and will be featured in Departmental social media. More information will be available on Canvas by the end of January.

Course schedule (subject to change)

Week	Date	Monday	Wednesday	Reading(s)	Assignments due & Quizzes
1	1/7, 1/9	Course introduction	Production trends	Course Syllabus	Quiz 1 Introductory survey
2	1/14, 1/16	Natural resource considerations in agricultural production: climate, soil, water and sunlight utilization		-Chapters 8, 10, 12 in *Introduction to Agronomy* -MSU Extension: Climate Change & Greenhouse Gas Basics	Quiz 2
3	1/21, 1/23	No class MLK Holiday	Introduction to peer review	-Hatfield et al. 2009 *Nitrate-nitrogen patterns in the Raccoon River Basin related to agricultural practices*	Quiz 3
4	1/28, 1/30	Overview of management practices for corn and soybean management		-Chapter 14 in *Introduction to Agronomy* -NebGuide: Corn and Soybean Pocket Guide	Quiz 4
5	2/4, 2/6	Introduction to farming simulation tool "APSIM"	Wheat management Nathan Mueller, UNL Extension	-APSIM introductory materials -UNL Extension wheat resources	Quiz 5
6	2/11, 2/13	Water and nutrient management		NebGuide 1850: Irrigation Management for Corn NebGuide EC 117: Fertilizer Suggestions for Corn	Quiz 6 Part 1 Peer review activity
7	2/18, 2/20	Farming simulation (APSIM) activities: corn, soybean, wheat management - cultural practices, fertility, and water		-NebGuide: Corn and Soybean Pocket Guide -APSIM introductory materials	Quiz 7 (cancelled due to weather) Part 1 Farming simulation activity
8	2/25, 2/27	Cover crop intro activity & Greenhouse safety	Cover crop seeding rate activity - Greenhouse	USDA-SARE: *How to manage cover crops profitably* Pages 7-15	Quiz 8
9	3/4, 3/6	Cover crop challenge: group planning & planting greenhouse experiment		USDA-SARE: *How to manage cover crops profitably* Pages 16-43	Quiz 9 (rescheduled from 2/20) Cover crop seeding rate activity
10	3/11, 3/13	Midterm review & writing exam questions	Midterm Exam		

Week	Date	Monday	Wednesday	Reading(s)	Assignments due & Quizzes
11	3/18-3/22	Spring break			
12	3/25, 3/27	Cover crop challenge: planting field experiment & equipment demo	Peer review in class activities	-Assigned articles to read for review of peers' student videos (schedule will be made available on Canvas)	Quiz 10/11 (25 points) Part 2 Peer review activity
13	4/1, 4/3	Site specific management, aerial imagery & advanced farming simulations		-NebGuide: Getting Started with Drones in Agriculture	Quiz 12
14	4/8, 4/10	Field activity: evaluating soils, crops and weeds in a corn-soy-wheat-cover crop experiment Microsoft Excel Cropping systems		-Nebraska 2017 on-farm research results (Pages 8-10: Introduction to experimental design) -Chapter 11 & 13 in *Introduction to Agronomy*	No quiz Part 3 Peer review activity (4/8) Part 2 Farming simulation activity (4/10)
15	4/15, 4/17	Integrated pest management and herbicide resistance	End of cover crop activity: Greenhouse and field experiments	-Chapter 15 in *Introduction to Agronomy* -Weed Science Society of America: "Superweed" information	No quiz
16	4/22, 4/24	Climate change impacts for agriculture	Final review & writing final exam questions	-Michigan State Extension: Ensuring Sustainable Agriculture in the Face of a Changing Climate -National Climate Assessment 4 (2018): Northern Great Plains & Agriculture/Rural Communities (Executive Summaries)	No quiz Part 2 cover crop challenge
17	4/30, 5/1	Finals week Section 1: Tuesday, April 30, 7:30am-9:30am Section 2: Wednesday, May 1, 3:30pm-5:30pm			

Technology
We will actively use technology in most lectures throughout the semester. This will include activities such as searching for information in small group discussions, participating in class-9wide online polls, and for weekly quizzes (administered through Canvas). It is expected that students have either a tablet or laptop with internet accessibility to complete quizzes and activities in class. Please speak with me if this is a concern, as there are some laptop computers available through the Department that can be used. Although technology will be used to enhance the learning environment, inappropriate use (i.e. browsing Facebook during class, responding to emails, sending non-emergency messages) can contribute to a disruptive and distracting learning environment. If technology use becomes a distraction to myself or other students, points will be deducted at my discretion.

Outdoor and greenhouse activities
During class on March 11, April 8, April 10 & April 17 (weather permitting), we will have class outside to conduct our own experiments with the field trials, located approximately a 10-15 minute walk from Plant Sciences Hall on East Campus. We will also work on the cover crop activities in the Teaching Greenhouse on several occasions. As we get closer to these dates, we will discuss further expectations and activities. Please come prepared to be outside and with appropriate footwear.

Groups and seating arrangements
After the first week of the class, students will be assigned tables and groups. Groups will rotate periodically (i.e. monthly) during the semester. Students will work in groups for in-class activities that will occasionally provide opportunities to earn extra credit for thoughtful participation and thorough note-taking. For example, we will begin most Monday classes with ~10 minutes for small group discussions on news articles related to agriculture. Other discussion-based activities will be conducted in groups may also come with extra credit opportunity.

Classroom climate
Thoughtful, critical, and respectful participation is not only encouraged, it is expected. I understand that participating in class can be a challenge for some, and so I ask us all to be responsible for creating a class atmosphere of mutual trust and respect so that everyone's questions can be expressed and constructively addressed. Any behavior in class that violates this will result in a grade penalty or removal from class at my discretion.

Academic Integrity
"Academic integrity is an essential indicator of the student's ethical standards. For this reason students are expected to adhere to guidelines concerning academic honesty outlined in Section 4.2 of University's Student Code of Conduct which can be found at http://stuafs.unl.edu/ja/code/three.shtml. Please speak with me to seek clarification of these guidelines if you have questions and/or potential concerns.

Experiencing difficulties?
If you are experiencing difficulties in this class, please visit with me to discuss on how you can respond to improve your performance. If you find you are having general difficulties with more than just one class, you should schedule an appointment with your advisor to discuss things and get their perspective and recommendations. If you are experiencing difficulties with more than classes, you may want to take advantage of the CASNR CARES program

(http://casnr.unl.edu/casnr-cares) and make an appointment with Nicole Smith, Student Development Coordinator (nicole.smith@unl.edu; (402) 472-0609) in 103 Ag Hall. If you feel like you are overwhelmed and you are experiencing general problems, do not hesitate to contact the Counseling and Psychological Services office in the Student Health Center (http://health.unl.edu/counseling-and-psychological-services-caps; (402) 472- 7450).

Special Needs
Students with disabilities are encouraged to speak with me for a confidential discussion of their individual needs for academic accommodation. It is the policy of the University of Nebraska-Lincoln to provide flexible and individualized accommodation to students with documented disabilities that may affect their ability to fully participate in course activities or to meet course requirements. To receive accommodation services, students must be registered with the Services for Students with Disabilities (SSD) office, 132 Canfield Administration, 472-3787 voice or TTY.

Emergency responses
Fire Alarm (or other evacuation): In the event of a fire alarm: Gather belongings (Purse, keys, cellphone, N-Card, etc.) and use the nearest exit to leave the building. Do not use the elevators. After exiting notify emergency personnel of the location of persons unable to exit the building. Do not return to building unless told to do so by emergency personnel.

Tornado Warning: When sirens sound, move to the lowest interior area of building or designated shelter. Stay away from windows and stay near an inside wall when possible.

Active Shooter

- **Evacuate**: if there is a safe escape path, leave belongings behind, keep hands visible and follow police officer instructions.
- **Hide out**: If evacuation is impossible secure yourself in your space by turning out lights, closing blinds and barricading doors if possible.
- **Take action**: As a last resort, and only when your life is in imminent danger, attempt to disrupt and/or incapacitate the active shooter.

UNL Alert:
Notifications about serious incidents on campus are sent via text message, email, unl.edu website, and social media. For more information go to: http://unlalert.unl.edu. Additional Emergency Procedures can be found here:
http://emergency.unl.edu/doc/Emergency_Procedures_Quicklist.pdf

Appendix B

Farming simulation assignment information

The objective of these activities is for you to gain familiarity with tools that can help you make crop management decisions. We will utilize the farming simulator tool *APSIM* to aid in crop management decision-making, develop hypotheses about environmental and/or management changes, and predict subsequent outcomes.

Part 1 of this activity is due on Wednesday, February 20 and will be worth 25 points. It should be completed on Canvas (a quiz will be set up) and will ask you to plan your experiment and to develop a hypothesis. In my professional experience, the best experiments are those that are well planned, and the careful planning of details can take a lot of time!

In Part 2 you will run your experiment, analyze results, and describe outcomes. This should be turned in via Canvas on Wednesday, April 10 and will be worth 75 points.

Part 1

All questions below should be answered in complete sentences.

Describe the management decision(s) and environment you will explore in your project. Note that this can be similar to examples that were discussed in class, but should still be sufficiently different. (5 points)

List the hypothesis that you will explore in your experiment. This should describe your independent variables (i.e. environmental factors, management factors – factors that we are altering in the experiment), the dependent variables (i.e. yield, leaf area index, transpiration, soil nitrate – factors that are impacted by the independent variables) and what you predict the effect to be. Remember that the hypothesis should be testable; in this assignment, it should be supported with evidence that you will generate through the simulation. (10 points)

The reason I have selected this topic is:

In this question we would like you to explain why you are interested in this topic. (2 points)

Describe the below files/information that you will use to set up your simulation. If you plan to create new climate files or soil profiles, describe how you plan to do so. (2 points each)

-Climate file

-Soil profile

-Output variable(s) - plan to evaluate at least two

List at least two additional references that you will use to create as realistic a simulation as possible and what you will compare the predictions to, such as extension publications, public data sources, or prior research experiments conducted by industry, extension, etc. (2 points)

Part 2

Your report should be uploaded as a word file and should address all of the below questions. It should also include at least two graphs that are labeled with enough information (axes, different treatments, etc.) for us to interpret.

1) Explain your simulation (i.e. describe the management and environment) explored in your project and why you selected it. Include any additional resources that you consulted to make the simulation more realistic.(10 points)

2) What was your hypothesis? (5 points) Did you find your hypothesis proven to be true or false? Explain in detail. (10 points)

3) Include at least two graphs from your simulation. Explain what you see in the graphs. How did the dependent variables that you explored change with different independent variables? (15 points)

4) What additional information or variables did you explore to try to explain what might have occurred in your simulation? Based on your prior knowledge and/or topics discussed in class, try to explain why the results may have turned out as they did. (10 points)

5) Explain in at least two sentences the most important thing(s) that you learned from this experiment. (5 points)

6) Explain how you could envision using decision-support tools such as the farming simulation platform APSIM in your future careers in agriculture. (5 points)

7) Explain any issues that you experienced during the set up and successful completion of your simulation. (5 points)

8) What additional information would have been helpful to your learning before we started or during these activities? (5 points)

9) List at least three additional questions that came up during the course of your working on this exercise that you would want to answer, or possibly how you might set up another simulation to explore some of these questions. (5 points)

Appendix C

Grading Rubric: Farming Simulation Assignment Part 2

Criteria	Ratings					Pts
	5.0 pts	**3.0 pts**	**0.0 pts**			5.0 pts
Explanation of experiment	**Professional**	**Somewhat professional**	**Unprofessional**			
	Thoroughly explained experiment	Experiment explained in some detail	No explanation of experiment			
	5.0 pts	**3.0 pts**	**0.0 pts**			5.0 pts
Resources included	**Professional**	**Somewhat professional**	**Unprofessional**			
	Included at least two resources	Included at least one resource, and/or resources that were not as relevant	Resources not included			
	5.0 pts	**3.0 pts**	**1.0 pts**	**0.0 pts**		5.0 pts
Hypothesis	**Professional**	**Somewhat professional**	**Somewhat professional**	**Unprofessional**		
	included a hypothesis was clearly developed before the experiment was initiated, thorough level of detail	included a hypothesis was clearly developed before the experiment was initiated, some level of detail	included a hypothesis that was *not* clearly developed before the experiment was initiated	No hypothesis included		
	10.0 pts	**8.0 pts**	**3.0 pts**	**0.0 pts**		10.0 pts
Hypothesis proven true or false	**Professional**	**Somewhat professional**	**Somewhat professional**	**Unprofessional**		
	strong detail to support *what* could happen and why, based on hypothesis that was clearly developed before experiment was initiated	some detail to support *what* could happen and why, based on hypothesis that was clearly developed before experiment was initiated	some detail to support *what* could happen and why, but was not based on a hypothesis that was clearly developed before experiment was initiated	no explanation presented for what might have happened in the experiment and why		
	15.0 pts	**12.0 pts**	**9.0 pts**	**6.0 pts**	**0.0 pts**	15.0 pts
Graph interpretation	**Professional**	**Somewhat professional**	**Somewhat professional**	**Somewhat professional**	**Unprofessional**	
	two graphs included, thorough explanation of both independent and dependent variables	two graphs included, some explanation of both independent and dependent variables	graph(s) included without adequate explanation of variables	no graphs included but some explanation of changes included	no graphs, no explanations for changes included	

	5.0 pts	**3.0 pts**	**0.0 pts**			
Resources included	**Professional**	**Somewhat professional**	**Unprofessional**			
	includes detailed discussion of prior knowledge and/or additional resources consulted	includes some discussion of prior knowledge and/or additional resources consulted	no discussion of prior knowledge and/or additional resources consulted			5.0 pts
	5.0 pts	**3.0 pts**	**0.0 pts**			
explaining what happened in the simulation	**Professional**	**Somewhat professional**	**Unprofessional**			
	Thoroughly explains a process for what might have occurred in the experiment	Some explanation for a process for what might have occurred in the experiment	No explanation for a process for what might have occurred in the experiment			5.0 pts
	5.0 pts	**3.0 pts**	**0.0 pts**			
what was learned	**Professional**	**Somewhat professional**	**Unprofessional**			
	two sentences included about what was learned	less than two sentences included about what was learned	No answer			5.0 pts
	5.0 pts	**3.0 pts**	**0.0 pts**			
how you might use tools like this in the future	**Professional**	**Somewhat professional**	**Unprofessional**			
	detailed explanation included	some explanation included	no explanation included			5.0 pts
	5.0 pts	**3.0 pts**	**0.0 pts**			
issues encountered	**Professional**	**Somewhat professional**	**Unprofessional**			
	detailed explanation included	some explanation included	no explanation included			5.0 pts
	5.0 pts	**3.0 pts**	**0.0 pts**			
additional information that would have been helpful	**Professional**	**Somewhat professional**	**Unprofessional**			
	detailed explanation included	some explanation included	no explanation included			5.0 pts
	5.0 pts	**3.0 pts**	**0.0 pts**			
additional questions	**Professional**	**Somewhat professional**	**Unprofessional**			
	three questions	less than three questions	no questions			5.0 pts
Total Points: 75.0						

Appendix D
Additional student feedback

Select student answers to the prompts "Explain any issues that you experienced during the set up and successful completion of your simulation" and "What additional information would have been helpful to your learning before we started or during these activities?"

Student quotes
The biggest problem that I experienced when trying to work with the simulation was getting all the variables to work with each other, and setting up the timeline of events
In general, it would have been nice to have spent time in class building simulations. In class, we just worked on reading the simulations that were already made-up for us. I really liked the activity but it would have been nice to have more information.
Additional information I explored that was rather difficult to figure out was the nitrogen content in the soil that I used. Having to manually go into the program and change different amounts of nitrogen gave different results.
Practice activities: we only got the demo activity that the professor did in class, but I think that wasn't sufficient for my learning. I think it would have been easier for me to have a much deeper understanding about how to work around the software if there were lots of practice problems. Even though I would have struggled with them at first, it would have been a big opportunity for me to gain a bigger picture into how the software works so that I would be well equipped for my own project.
Though I did not get errors in my simulation, it would have been to know the common ways to make mistakes so that students work towards not making one of those mistakes. But frankly speaking, we spent enough time in class working with the APSIM and we received extra informational videos about how to work with the system. So, I think it was up to us to use all of those resources and practice running simulations (which we did anyway) to become more familiar with the simulator.
It would have been nice to have a screencast of how to create a file from scratch. There were only screencasts of simulations that had already been put together.
Although we spent quite a bit of time using APSIM in class, we only dealt with pre-made simulations. I encountered challenges when attempting to design my own simulation. I watched the provided videos and thought I had everything set up correctly, but was still receiving errors. The APSIM program does provide an interesting opportunity to investigate the effects of management practices on many output variables, but does not seem to be for beginners and is definitely not user friendly. For these reasons, I opted to abandon my previously planned experiment and use the alternate option for completing this assignment.
The simulation was not an easy task given that it was a new learning approach to me. I had a few difficulties mainly to familiarize with the system. First, this model is designed to operate on windows computer which I didn't have. So, I had to go through many processes to download windows parallels and software on my MacBook, but it wasn't that difficult. The issues lied in using the software. At first, I didn't know what was going on either in class or after. Eventually, I got cozy with the system.
The APSIM simulation is very difficult to get a basic understanding on how to run the simulations. If the user interface was simpler then I believe it would be a very useful tool. Also if they had a MAC version it would have been nicer so I didn't have to spend money on Windows 10. Overall, once you run multiple simulations it becomes easier to understand but I still found myself going through the guide for assistance.
The software is not very user friendly so it is difficult to put in your inputs and your variables to make changes to what you would like to run. Overall it was very difficult and confusing using the APSIM software even after using it in class before this project. After running simulations in class I was still not very confident in my ability to use the software.

The issues that I had when working with the simulation was the going though different processes. APSIM was not easy to use because it requires different parts. For the part I simulation assignment, I started using soybean row spacing in Rwanda but it was hard to find the data. I decided to change everything such as the place, the hypothesis so that I can be able to get the data which are enough to run the simulation. I can say that the issue was the difficulties in finding the data and using the application in general.