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Enhancing User-Defined Agricultural Projects with Commodity Modeling and Strategic Positioning

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Abstract

This full paper addresses the question of whether introducing a strategic component into team projects leads to greater student learning and participation. This research examined the integration of a financial component, using grain commodities, into a team project in the agriculture sector. Students were given a user-defined project related to agriculture in a freshman-level engineering project class. This project introduced students to new technologies and topics they may not have considered within the agriculture field.

A new learning module focused on modeling grain commodities was added to the course, along with a feature for students to sell their acquired grains during the project. The student teams were presented with user scenarios from the agriculture sector, such as challenges related to automated irrigation conservation, equipment safety, and the efficient use of equipment, chemicals, and grains. The teams were allowed to pick their desired project; however, a commodity was assigned to each project. For example, a project linked to irrigation had corn as the associated commodity. Assigning commodities to the project added a strategy component to the selection process. The students learned about the commodities involved with the project, including corn, cotton, soybeans, and wheat, and they modeled the possible outcomes for both one-year and five-year returns based on historical market data from the past decade.

The teams had to consider both their projects' technical solutions and the associated commodity's financial prospects. The teams were ultimately assessed on a mechatronic prototype using a microcontroller and the financial returns achieved from selling their commodity during the project timeframe. Success was determined by the teams' understanding of the prototype solution for the user and their strategic decision-making in managing commodity trades. Adding the commodity module helped students understand the economic drivers in the agriculture sector and how the global commodity markets fluctuate.

The outcomes of this study were measured using survey instruments that were administered before the commodity and microcontroller learning modules and upon completion of the user-centered agriculture project. Ultimately, the students showed significant technical growth and understanding of the user-defined problem. The use of commodities as a strategy-based activity during the project was motivating for the students. This paper discusses the results of the surveys, focusing on the students' perceived learning regarding commodities and agricultural concepts, teamwork growth, and motivation for engaging in the project with a strategic component included.

Introduction

Teaching methods have developed over the years, with strategy-based activities being an approach that is interactive and interesting for students. It is important for students to understand the concepts and be able to apply them effectively in their assignments. A strategy component was added to an established user-defined project in a freshman-level engineering course. The students had to find solutions to problems in the agriculture sector. A learning module about commodities and how they relate to these problems was added to the project. The students had to model and then strategically sell their commodities to maximize their profits during the duration of the project. This paper describes the course and the project in more detail, discusses the commodities used during the project, and how this topic was implemented in the course and the project. Next, this paper will present the results of surveys given in the course, followed by conclusions and future work.

Background

As digital learners, today's college students need faculty to reassess content delivery methods that incorporate technological innovations and diverse learning environments. One approach that resonates with students is gamification in education, which applies game-like elements to routine tasks [1, 2]. Game-based learning provides an interactive and engaging method for students to explore topics that might otherwise seem mundane. By leveraging gamification, faculty can spark interest and motivate students to solve problems, acquire knowledge, and develop both technical and social skills through gameplay [3-5]. Research by Subhash and Cudney highlights the benefits of this approach, including improved academic performance and increased student participation [5]. Integrating game-based strategies enables faculty to create more impactful and meaningful learning experiences for college students.

The term "gamification" was coined by Pelling in 2002, while the concept of "serious games" underscores the intentional design of games to achieve specific educational objectives [6]. According to Caponetto et al., serious games are instrumental in enhancing student motivation and increasing engagement with the learning process [7]. Game-based strategies go beyond traditional methods by incorporating real-life scenarios that challenge students to make decisions, thereby promoting critical thinking and decision-making skills in an educational setting. Gamification taps into human psychology by leveraging the desire for competition and achievement. This experiential learning approach not only enriches the academic experience but also prepares students for their future careers [8].

Recent business education models further highlight the importance of teamwork, critical thinking, and real-world applications in modern education systems [9,10]. By presenting students with realistic challenges, gamification gives them decision-making capabilities that are essential in professional environments. Compared to conventional teaching methods, game-based strategies have demonstrated a higher success rate in achieving learning objectives [11].

In alignment with these findings, the primary focus of this research was to investigate how strategy-based activities supported learning and motivation in an engineering project class. This approach aims to improve the learning process and outcomes [12]. Additionally, strategy-based activities encourage students to explore complex topics, such as commodities, through interactive and incentivized learning experiences [12]. By leveraging the strengths of strategic gameplay, faculty can transform traditional learning environments to encourage curiosity and engagement in the course.

Freshman-Level Project Class

A learning module about commodities and commodity forecasting was added to a freshman-level project course. Through the general engineering degree program at Arizona State University, the students must take a project class every semester. The Foundations of Engineering Design II is the second project course that engineering students complete in the general engineering curriculum that all the students in the degree program must take. This class focuses on the engineering design process, modeling, basic electronics, microcontroller programming, teamwork, and communication. A typical section has thirty to forty students. Two sections were presented with a user-centered project in the agricultural sector, where the user was a farmer. They had to empathize with the user, understand the problems presented, and benchmark possible solutions. The problems given to the students were actual problems that the farmer faced including automatic control and conservation of water, planting, harvesting, and chemical application. The students were asked to use a microcontroller to develop such prototypes as an autonomous grain cart, self-adjusting irrigation systems, planters, and sprayer booms. To include economic considerations in the project, each problem was paired with a related commodity. The project lasted six weeks during the end of the semester. The strategy component of the project was presented to the students at the beginning of the project. They could select their problem to solve and prototype based on the commodity they would receive. The students were also presented with the options of holding onto the commodity or selling the commodity in every class after the current prices were listed. All of the projects and commodities were investigated in the two class sections.

Commodities

Commodities are unprocessed goods that vary by quality, and agricultural commodities are highly sensitive to factors such as adverse weather conditions, natural disasters, changes in global supply and demand, and exchange rate instability. In recent history, the variability of agricultural commodity prices has been particularly pronounced [13]. These unpredictable price variations cause uncertainty that increases risks for consumers, traders, producers, and governments [14]. As a result, the notable volatility in commodity prices in recent years has raised concerns about macroeconomic stability and overall economic performance [15].

The complexity of commodity markets is further compounded by the heterogeneous structure of commodities themselves [16]. This variation in quality and characteristics makes it difficult to pinpoint a consistent set of factors that could explain the common variation in commodity returns. The unique nature of each commodity, combined with external economic pressures, underscores the challenge of developing accurate predictive models for pricing and market behavior. Given these challenges, it becomes increasingly important for stakeholders to understand the underlying factors driving commodity price volatility and determine strategies for mitigating the associated risks.

For the commodity learning module, the students examined corn, cotton, soybeans, and wheat as the four potential commodities. The students looked at market trends for the last decade and then were asked to use Excel to determine a model to predict future prices for one and five years in the future. Students worked individually on the modeling activity. When selecting the project as a team, they had to decide which problem to solve and predict the performance of the associated commodity. The students were given the price of the commodity on the first day of the project. They had to retain the commodity for one week before they could sell the commodity during the remaining five weeks of the project. The students were made aware of the current global forces affecting commodity prices during the project timeframe. Adding the strategy of selling commodities helped students remain motivated throughout the duration of a long-term project by tracking the daily price fluctuations.

Survey Instruments

This study aimed to determine the impact of a strategy-based learning module on 1) students' understanding of microcontrollers, agriculture, and commodities, 2) teamwork skills, and 3) project enjoyment. The hypothesis was that due to strategy-based activities, students would want to learn more about microcontrollers and agriculture and strategize with their teammates to complete the project. This would increase their understanding of microcontrollers, agriculture, commodities, and team coordination, resulting in a successful user-defined project.

Rajendran and Shah created a questionnaire to assess students' perceptions of gamification and collaboration, followed by a second questionnaire focused on the knowledge content and details of the game used in their English language learning module [17]. Similarly, Manzano-Leon et al. developed a questionnaire that addressed improved knowledge content, motivation for the material, learning experiences with classmates and team members, and overall enjoyment of the activity [18]. Drawing from these previous studies, three measurement variables were selected for this research. The perceived knowledge gained and interest in microcontrollers, agriculture, and commodities, improved teamwork, and enjoyment of the project and strategy-based activities.

The experimental method consisted of administering a pre-survey before the students started the learning modules about microcontrollers and commodities, and a post-survey after the project. Relational data in the form of closed questions were collected from the students through two surveys. The data collection method was selected to assess the students' perceived knowledge, as well as their growth and motivation. The research design then focused on existing knowledge and the formulation of appropriate questions to ask. A pre-survey was given for a base assessment of the students' knowledge and interest in agriculture, commodities, and microcontrollers and their perceptions of projects and working in teams. Lastly, a post-survey was administered to assess growth compared to the pre-survey and to evaluate perceived motivation and growth. The reliability and consistency of the survey responses were measured using the Cronbach Alpha coefficient value. The Cronbach Alpha coefficient is used as a reliability estimate and is a useful calculation when compared to other reliability estimate algorithms [19].

The questionnaires were created using a standardized survey format. All the questions utilized a 10-point Likert scale, eliminating a neutral response, with ratings ranging from "Strongly Disagree" for 1 to "Strongly Agree" for 10. The questions were all closed questions. No open-ended questions or space for comments were included in the survey. Students were allowed only one answer per question on the numbered scale. The pre-survey was administered before the students started the learning modules. The post-survey was given at the conclusion of the project and started with the same first five questions from the pre-survey to gauge the growth in understanding and interest in agriculture, understanding of commodities and microcontrollers, and strategy-based activities. The last five questions were related to topics about teaming, strategy-based activities, growth in agricultural knowledge, and enjoyment of the project. The pre-survey and post-survey questions are detailed in Figure 1.

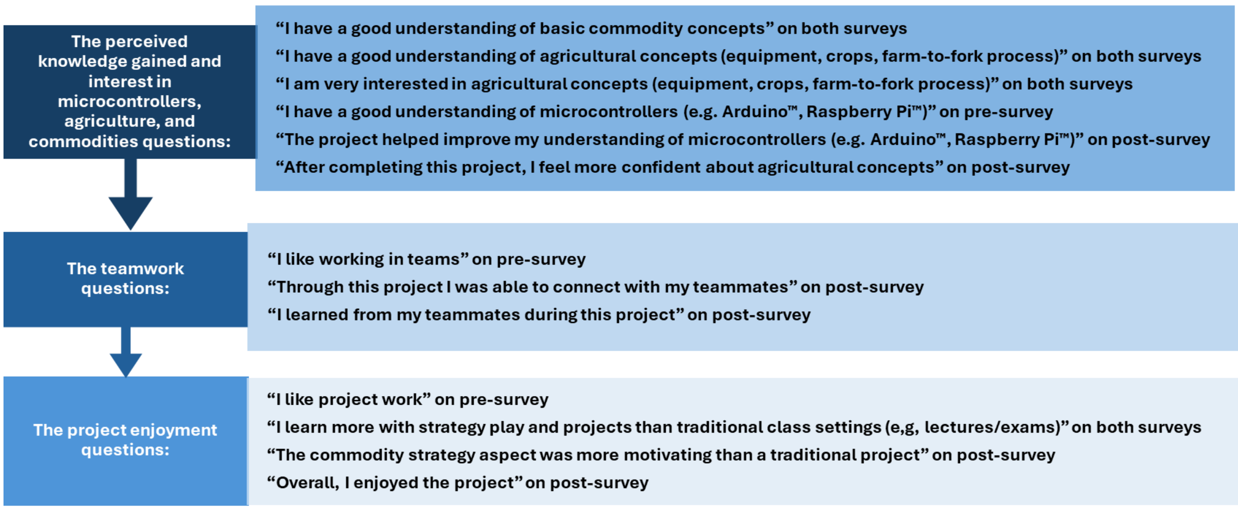

Figure 1: The questions administered on the pre-survey and post-survey aligned with project learning goals.

Data Analysis

The data analysis involved examining the pre-survey and post-survey results, followed by a comparative analysis of both surveys to measure the growth in each category. The survey used a Likert scale from 1 to 10, so the mean and first and third quartile values were tabulated for each question and shown in the graphs. The pre-survey results are shown in Figure 2. The pre-survey was given to 63 students across two class sections with 61 respondents during the Fall 2024 semester. The question numbers in Figure 2 refer to the following questions:

1. "I have a good understanding of basic commodity concepts"
2. "I have a good understanding of microcontrollers"
3. "I have a good understanding of agricultural concepts"
4. "I am very interested in agricultural concepts"
5. "I learn more with strategy play and projects than traditional class settings"
6. "I like working in teams"
7. "I like project work"

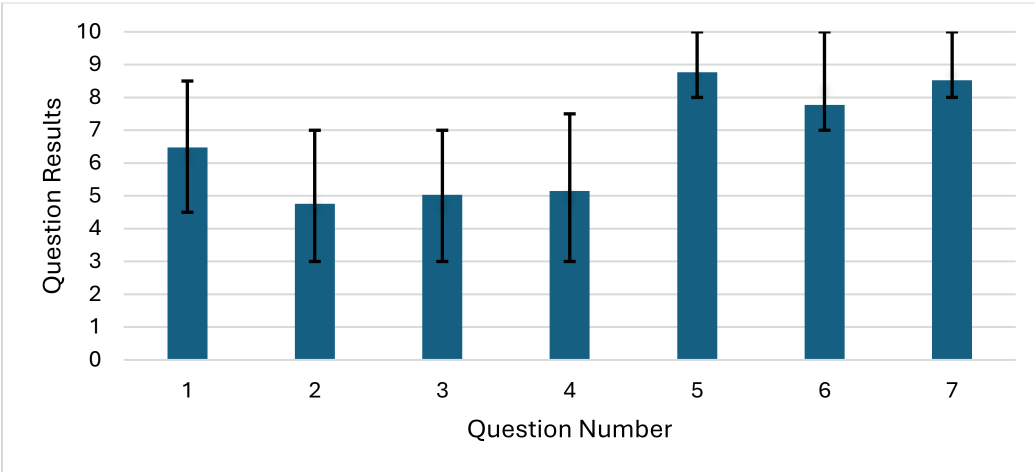

Figure 2: Response to pre-survey questions with the blue bars indicating the average response and the bar lines indicating the first and third quartile of the responses.

Surprisingly, before the commodities learning module students felt they had a good basic understanding of commodities as shown in Question 1, but not as much with microcontrollers (Question 2) and agricultural concepts and interests (Questions 3 and 4). There was a jump in the average response numbers for Questions 5-7. These questions indicated that students perceived that they learned more with strategy play and projects, and liked working on projects slightly more than they liked working in teams. The Cronbach Alpha value for the pre-survey was 0.61, which was an acceptable value for the consistency and reliability of the survey.

The post-survey was given to 56 students across two class sections with 52 respondents after the end of the project, during the Fall 2024 semester. The question numbers in Figure 3 refer to the following questions:

1. "I have a good understanding of basic commodity concepts"
2. "The project helped improve my understanding of microcontrollers"
3. "I have a good understanding of agricultural concepts"
4. "I am very interested in agricultural concepts"
5. "I learn more with strategy play and projects than traditional class settings"
6. "I learned from my teammates during this project"
7. "Through this project I was able to connect with my teammates"
8. "The commodity strategy aspect was more motivating than a traditional project"
9. "After completing this project I feel more confident about agricultural concepts"
10. "Overall, I enjoyed the project"

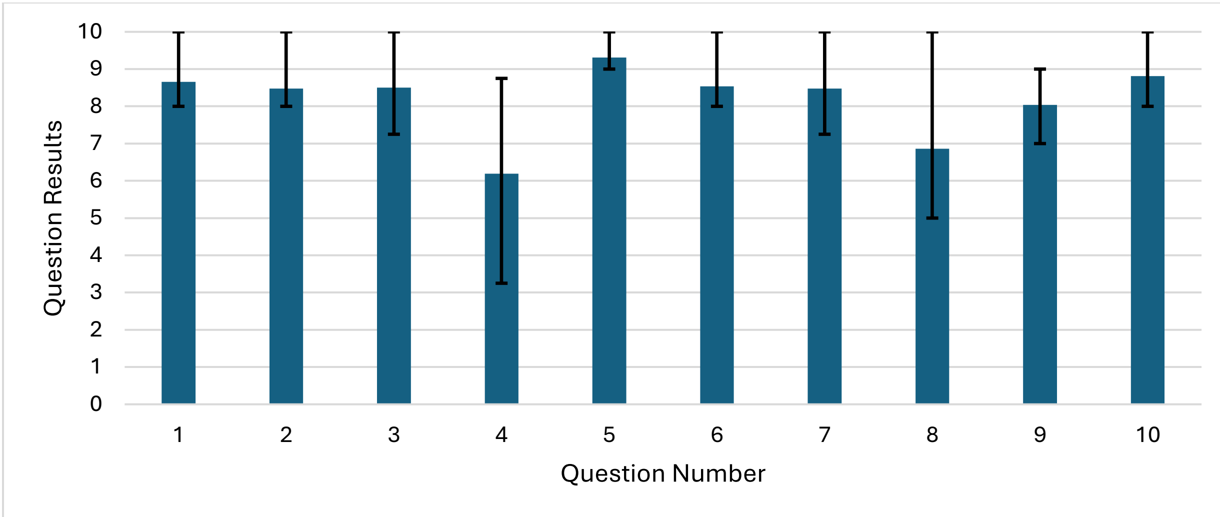

Figure 3: Response to post-survey questions with the blue bars indicating the average response and the bar lines indicating the first and third quartile of the responses.

There was significant growth in the perceived understanding of agriculture, commodities, and microcontrollers as seen with the first three questions. The other repeated questions “I am very interested in agricultural concepts” and “I learn more with strategy play and projects than traditional class settings”, questions 4 and 5 respectively, both had growth. The mean interest in agricultural concepts grew from 5.15 to 6.19, and the 3rd quartile went from 7.5 to 8.75 as shown in question 4 on both surveys. The interest in strategy play appeared as question 5 on the pre-survey and post-survey had an increase from 8.77 to 9.31 with the lower quartile jumping from 8 to 9. Questions on teaming showed growth, question 6 from the pre-survey had an average response of 7.77, and questions 6 and 7 in the post-survey had average responses of 8.54 and 8.48. The questions regarding project enjoyment also remained high, questions 5 and 7 in the pre-survey had average responses of 8.77 and 8.52, and correspondingly questions 5 and 10 in the post-survey had average responses of 9.31 and 8.81. Question 8 on the post-survey, “The commodity strategy aspect was more motivating than a traditional project” had an average response of 6.87, however, the lower quartile was 5 and the upper quartile was 10. This indicated that the result was mixed, with approximately a quarter of the students not as motivated by the strategy-based activity, but a majority of the students finding it motivating. Questions 9 and 10 on the post-survey indicated that the students felt more confident about agricultural concepts with an average response of 8.04 and enjoyed the project with an average response of 8.81 and lower and upper quartiles of 8 to 10, respectively. The Cronbach Alpha value for the post-survey was 0.74 which, was an acceptable level for the consistency and reliability of the survey. Two One-Sided Tests (TOST) were performed on the five repeated questions to test for equivalence of means. The TOST test showed significant non-equivalence for the first three questions and relative non-equivalence for the last two questions. All five questions were found to be non-equivalent in their mean results.

A comparison of questions 1-3 from the pre-survey to the post-survey is shown in Figure 4. The perceived knowledge of commodities grew from an average response of 6.48 on the pre-survey to 8.65 on the post-survey. The first and third quartile ranges also shrunk from a spread of four on the pre-survey to two on the post-survey. This indicated that the overall perceived knowledge of commodities for the entire class increased significantly. The perceived knowledge of microcontrollers increased from an average response of 4.75 to 8.48. The perceived knowledge of agricultural concepts increased from an average response of 5.03 to 8.5. The first and third quartiles for these two questions shifted significantly from the first quartiles jumping from 3 to 7.25 and 8, and the upper quartiles increasing from 7 to 10. The students had an overall perception that they had a much better understanding of microcontrollers, commodities, and agricultural concepts after the learning modules and project.

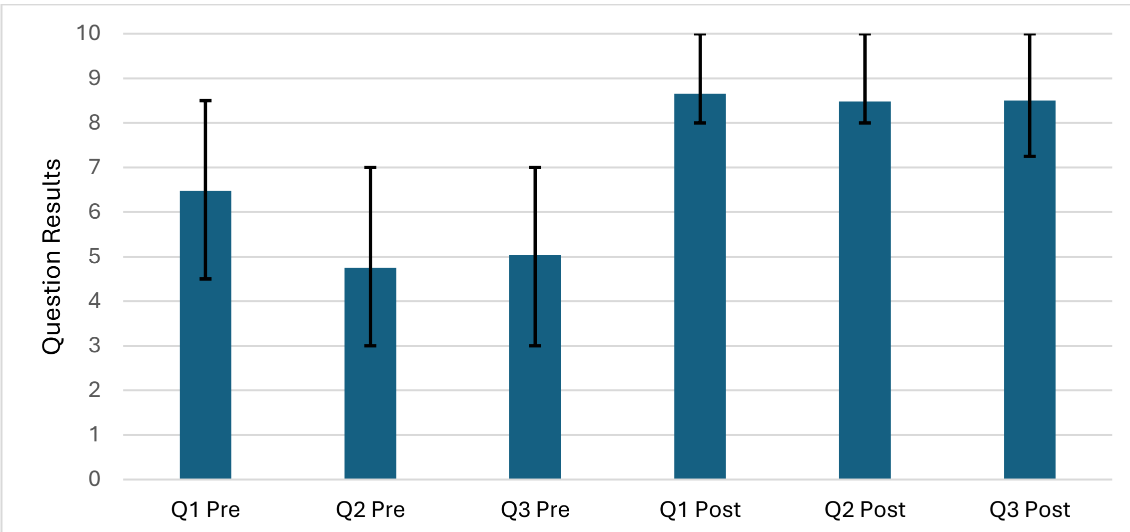

Figure 4: Growth from pre-survey to post-survey responses for Q1: good understanding of commodities, Q2: a good understanding of microcontrollers, and Q3: a good understanding of agriculture.

Anecdotally, there was more strategizing regarding project selection within the teams. During the selection of the project, students actively researched prices and when certain grains were planted or harvested to predict major swings in the market. On a daily basis, we would discuss the possible influences on the commodity prices, such as the Midwest receiving a nice rain after the wheat crops were planted. The students also showed significant interest in providing quality prototypes. If a commodity was not performing well during the project, the teams tended to focus on prototype construction to recoup any lost points from their commodity performance.

This study demonstrated the value of integrating real-world economic scenarios, such as commodity price fluctuations and market behaviors, into engineering education. By using Excel for commodity price modeling and incorporating microcontroller-based activities, the project effectively bridged theoretical knowledge with practical applications. Aligning course content with industry practices and global trends not only improved applicability but also motivated students through hands-on, practical learning. By combining technical expertise with economic and strategic decision-making, the project promoted a multidisciplinary skill set. These findings highlighted the potential of interactive and strategic learning approaches to increase student engagement, knowledge retention, and skill development.

Conclusion

Integrating learning modules about commodities and microcontrollers, and incorporating both into a project from the agriculture sector significantly enhanced students' knowledge in these areas. The survey results indicated that students experienced notable growth in their understanding of commodities, microcontrollers, and agricultural concepts. Students responded positively to teamwork-based learning and building connections with their teammates. Students were able to collaborate effectively to address complex strategies and challenges through collective problem-solving. The introduction of strategy-based elements, such as commodity trading and financial modeling, added a unique dimension to the course, encouraging students to apply critical thinking and real-world analysis to their decision-making process. Anecdotal evidence revealed that students took an active interest in researching market trends to optimize their selection based on potential commodity performance. This strengthened their understanding of global economic drivers in agriculture.

Future iterations of this course could explore additional flexibility in project parameters, such as allowing students to choose their commodities independently of their projects or permitting mixed commodity portfolios. These changes could provide students with a broader perspective regarding financial management and decision-making under uncertainty.

Incorporating the use of strategy activities into engineering project courses can significantly improve student engagement, motivation, and learning outcomes. However, the success of strategy-based activities depends on thoughtful implementation, ensuring that strategy elements support the educational goals of the course. When used effectively, strategy-based activities can enhance the overall learning experience, preparing engineering students for the collaborative and technological demands of the modern workforce.

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