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Introducing Industrial Systems Engineering to First-Year Students via Mr. Potato Head

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Abstract

This Complete Evidence-based practice paper explores the effect of a first-year engineering lab introducing students to industrial systems engineering (ISE) principles using the Mr. Potato Head toy to engage the students in active learning with a manageable product. One goal of a first-year engineering program is to effectively introduce students to a variety of engineering disciplines so that they can make appropriate choices for their careers at an early stage, but for some disciplines, creating engaging lab experiences can be challenging. This paper introduces the ISE lab presently being used by an honors first-year engineering program at The Ohio State University. The focus of the lab is to introduce the ideas of Lean Manufacturing and Six Sigma as well as different manufacturing systems used in industry. The lab was originally created in conjunction with the ISE department for use by the standard first-year program in a two-hour lab session, but the honors first-year program adopted and refined this lab for honors students over the last four years. By utilizing the Mr. Potato Head toy as a product to manufacture, the students can create different variants of the product using basic materials. Students are introduced to an inefficient manufacturing layout and compare manufacturing a small assortment of products using both push and pull sequential manufacturing systems. They then meet as a team and decide how to improve the process, where the inefficient initial process allows for a variety of improvements. The students then try their improved manufacturing process and create a report based on the strengths and weaknesses they observed from all manufacturing processes used.

The Mr. Potato Head toy has the advantages of being readily identifiable, being assembled without tools, and that students enjoying working with it. A variety of products can be produced with a reasonable number of failure modes to be tested by quality control and the customer ordering the product, whose role is filled by a teaching assistant. Students operate in different roles of the production process including the operators who construct the product, transporters who move the product, final testers who check the product, and the engineers who implement changes to the process to improve quality and productivity. Teams are given a cost model including costs for space utilized, worker salaries, work-in-progress, defects, wrong products, and more. A sales price for each product correctly delivered on time is also given. They then complete four product runs and keep track of how well their team performs financially. The first run is a trial run to make sure each student is familiar with the roles and process. The second is a push system, and the third is a pull system. Then the final run is adapted using student refinements to the process lead by the engineers who are tasked with maximizing profit.

This paper briefly describes the development of this lab and provides a synopsis of the instructional materials and implementation of the lab using the Mr. Potato Head toy. Data is provided to illustrate the student experience though this lab experience, and a discussion is presented about the benefits of the lab design for the students and the goals of the lab, as well as student feedback about the lab. The implication of this work is to describe the design and benefits of using this lab for introducing first-year engineering students to ISE principles so that a case is presented for its adoption and adaptation in other first-year engineering programs.

Introduction

An important part of a first-year engineering program is exposing students to engineering experiences. In many cases, students come to college without a full understanding of what it means to be a practicing engineer. Research has shown that stereotypes of what engineers are and what engineers do persist as early as elementary school [1]. First-year engineering programs often take on the task of providing students with engineering experiences to help mold their expectations of what an engineer does and what various engineering disciplines are available to them in an effort to improve retention [2].

As many different first-year engineering (FYE) programs have shown, students can be introduced to engineering experiences earlier in their education through course work, design projects, or lab experiences. A challenge of this discipline-exposure component of a first-year engineering curriculum is how to efficiently use course time to introduce so many different engineering disciplines in ways that are impactful and meaningful to students. One such way of providing first-year engineering students with engineering experiences in multiple disciplines is by incorporating a hands-on lab component into the course to introduce various activities from differing disciplines of engineering [3].

Course and Lab Background

First-Year Engineering Honors Lab

The first-year engineering program at Ohio State University was the result of the university's membership in a coalition in the early 1990's encouraging college engineering programs to engage students in more engineering experiences in their first year. The goal of the first-year engineering experience is to introduce new engineering students to a variety of engineering disciplines and teach them basic technical skills through a variety of in-class activities, labs, and design experiences. Ohio State's first-year engineering program is a two-course sequence with options for both a standard and honors track for students to select.

Over the last 5 years, the first-year engineering student population was made up by about 25% women and 75% men, 10% Asian, 3% Black, 5% Hispanic, and 71% White students. Additionally, about 16% of engineering students in the college were on a Federal Pell Grant during this timeframe [4]. While some students may have a general understanding of engineering disciplines before starting college, many may not. To counter these differences, this experience is designed with the goal for labs to help ensure that all students have a better understanding of these disciplines. This paper will discuss a lab implemented in the honors track of the first-year engineering program.

In the honors track, the first course in the two-course sequence has two primary components: the lecture portion and the lab portion. The lecture portion of this course is taught by the instructor, utilizing an inverted classroom approach [5], while the laboratory portion of the course is taught by a Graduate Teaching Associate (GTA), focusing on introducing students to various engineering disciplines through team-based lab experiences and technical writing assignments.

The instructional team for the lab consists of one GTA and four Undergraduate Teaching Assistants (UTAs). The GTA runs the weekly two-hour lab sessions by presenting the necessary background content and lab procedure information in the first twenty minutes of the lab time, and then assisting with student questions throughout the lab experience alongside the UTAs as the students complete the lab.

The purpose of the labs that students complete are to introduce various disciplines of engineering to first-year students, encourage teamwork and collaboration skills, and expose students to a variety of technical writing experiences through post-lab assignments. Lab experiences span multiple engineering disciplines (e.g. electrical engineering, computer engineering, civil engineering, biomedical engineering, mechanical engineering, aerospace engineering, and integrated systems engineering). Lab write-ups and GTA lectures frame the lab activity in the context of the engineering discipline being highlighted that week. In-lab activities are then conducted for students to experience different engineering processes or tasks, often collecting various forms of data to later analyze and discuss in a technical writing assignment. Fitting an engineering experience that is as authentic as possible into a two-hour time slot can be challenging, as students typically come in with little prior knowledge on many engineering topics. An additional consideration when designing these lab experiences is student engagement and learning. Some engineering disciplines have proven difficult to represent in an accurate but also academically engaging way. One such lab in the first-year engineering honors program that has been designed to fulfill both criteria of accuracy and academic engagement is the Quality and Productivity lab that introduces first-year engineering students to integrated systems engineering.

Quality and Productivity Lab Concepts

The Quality and Productivity lab was designed with emphasis on the students' understanding of the manufacturing processes and measures of success used in this setting. Students are asked to differentiate between a push system, where manufacturers make predictions on the demand for a product and begin creating it before receiving an order, and a pull system, where manufacturers wait for an order before starting the production of a product. One example of a product made using a push system is a smart phone charger that can be purchased at any consumer electronics store, while a pull system might be used for products that should not be made until the customer is ready for it, such as a small coffee at a café or a specialized robot arm from an engineering company. Students also need to be familiar with the different stages of a manufacturing process, following the flow of the raw materials through the process until the final product is sent to the customer. The lab also asks students to identify successful and unsuccessful practices used to make improvements to the manufacturing process in improving the quality and productivity of the process.

To help identify areas of improvement, students are taught about using lean manufacturing to reduce waste and inefficiencies in the system and using Six Sigma ideas to reduce variation in the products and processes, both helping to reduce the cost of production. Students are introduced to the DMAIC methodology in implementing improvements and while no specific quality-management tool is used, students are asked to identify aspects of the process that lead to variation in the product that they may reduce, as well as aspects that could result in waste that they may eliminate. While not all students are studying industrial systems engineering and will be analyzing manufacturing processes, the skills needed to study a process and implement changes to improve it can be useful to all engineers.

For each lab in the course, a scenario is presented to the students to help situate the experience and knowledge gained to an applicable context. Researchers have synthesized work to conclude that situating lab experiences into a specific context improves the technical writing outcomes of the students, allowing them to practice writing about their results in the context of a real-world engineering problem [6]. In this lab, students are posed with three opposing teams who compete to create the most profitable manufacturing process for a company developing the Mr. Potato Head toy. Students are split into these three teams and work to better understand the process and products and implement changes to maximize the profits for their team. Each team is given identical orders of variants of the Mr. Potato Head toy to construct and deliver to the customer within a given time.

Quality and Productivity Lab Experience

Learning Objectives

Through the use of learning objectives, instructors can communicate the topics they believe to be the most important for the students' learning so that students can focus on developing mastery of the identified skills [7]. To incorporate learning objectives into the lab, the lab was designed to include the following learning objectives:

1. Recall the general steps in a manufacturing process: raw material delivery, raw material staging, processing, work in progress staging, final testing, and transportation.
2. Define quality and productivity.
3. Define lean manufacturing and Six Sigma manufacturing.
4. Identify sources of waste and variation in a manufacturing process.
5. Identify value added and non-value added steps in a manufacturing process.
6. Identify metrics to measure, improve, and control in a manufacturing process.
7. Utilize principles of lean and Six Sigma to improve productivity and quality of a manufacturing process.
8. Differentiate between a push system and a pull system for a sequential manufacturing process.
9. Evaluate manufacturing models for strengths and weaknesses in terms of quality, productivity, and communication.
10. Compare manufacturing models in terms of effectiveness and profitability.
11. Write a cohesive group lab report based on different information and observations from each group member.

Materials and Resources

The Q&P lab uses the Mr. Potato Head toy for the students to manufacture, each which comes with various parts and accessories that allow for a variety of designs of the Mr. Potato Head toy to be used as different products for the lab, whose designs can be seen in Figure 1 on the following page. As seen in this figure, the designs differ in arm placement (seen by the lower arms in the Red and Yukon models versus the higher arms in the Spud model), hat type and direction (seen in differences between all three models), the inclusion of a mustache (seen by the mustache only present in the Yukon model), and eye orientation (seen by the 'reflections' in the eyes facing up in the Red and Yukon models but rotated to face down in the Spud model). Each team is provided with the parts of approximately 20 Mr. Potato Heads with the individual parts separated into bins: the bodies, feet, and hats are combined, the eyes and nose combined, and the mouth and mustache. Each bin is then given to the students who are tasked with constructing the Mr. Potato Heads using only one specific part each. A class of approximately 36 students is split into three teams, each with three tables, so that each team has seven operators for building the products, two transporters for moving the product between tables using provided bins, two Integrated Systems Engineers for analyzing the production line, and one final tester for checking the products before sending them to the customer or back to production to fix defects.

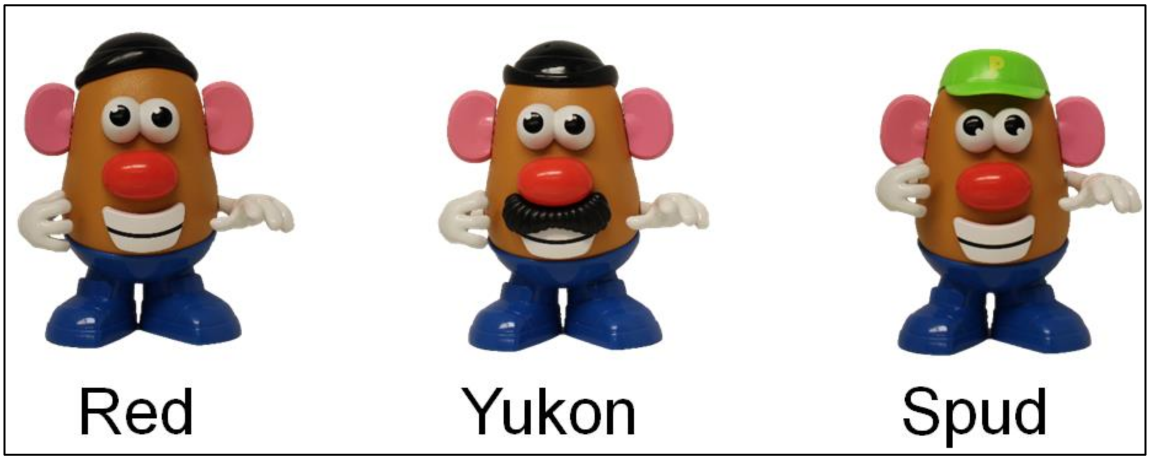

Figure 1: Mr. Potato Head products created in Q&P lab activity

To help prompt them to think about successes and potential improvements after each run, each student is provided with a reflection worksheet asking them "What went well at your position?", "What could be improved at your position?", and "How did the run go overall?" after each run, as well as questions about the specifics of each type of run and how it could be useful for their final run. These notes could be used when each team discussed the improvements to make for the final run, but they could also be used by each team after the lab when completing their lab report in discussing the process of the lab and what changes they wanted to see.

One UTA plays the role of the customer for each team, sending orders out to their respective team and checking for defects in the orders they receive. Each UTA holds an envelope for each run, each containing a card per order they have for their team that they can give to the team when an order is placed. These cards have information on what models of products an order asks for and how many, as well as the time the order is placed and when it is due. These cards also include what run and order number they are for so that the customers can coordinate to ensure each team receives the same order at the same time as the other teams.

Using a provided sheet, the customers keep track of the status of each order they make, including if the order was turned in on time or at all, what products were turned in, and the time that the order was delivered. Additionally, the ISEs keep track of the cost per run, affected by the number of tables, workers, and extra products they have, and the final testers keep track of the number of defects they had to send back, resulting in additional costs. The GTA running the lab uses an Excel spreadsheet projected to the students that automatically calculates and displays the total costs and revenue of each team, allowing each team to monitor their cost effectiveness and compare it to the other teams.

Student Lab Experience

At the beginning of the lab, the GTA introduces the scenario, where each team is competing to create the most profitable production line to propose to a newly expanding Mr. Potato Head production company. The GTA also reviews the ISE topics of interest in the lab, including the manufacturing process, push and pull systems, as well as lean manufacturing and Six Sigma. Next, all roles held by the students are discussed, including the operators, transporters, ISEs, and final testers so that all students have a better understanding of each role and how they affect the overall process. The operator roles are emphasized so that students understand what part each operator is responsible for and key differences between the types of Mr. Potato Heads models are discussed.

After the lab introduction, each team is split up and students are placed at the table corresponding to their roles; operators sit at a table where the parts they use are located, the final tester sits at a table with enough space to evaluate and sort products, and the transporters and ISEs walk between tables to move products and observe the production line, respectively. A five-minute trial run with only two orders is conducted in order to give all students the opportunity to practice their roles and become comfortable with the materials and process. Both orders are made available to the teams immediately, allowing all of the 5 minutes to be used to create two orders of one each of the three different models. After the trial run, the data is collected from the ISEs and customers to ensure they were collecting their data properly, customers review with the ISEs any defects they noticed to help clarify mistakes, the products are disassembled, and parts placed back into the corresponding bins. Any new or remaining questions are clarified with the GTA so that all teams understand their roles and the process they follow.

After the trial run, the teams perform two more test runs, a push run and a pull run. In the push run, ISEs are provided with a market estimate on the proportion of each product type (e.g. 25% Red, 50% Yukon, 25% Spud), allowing them to direct their team to begin making products before receiving an order. Customers hand out their orders after each minute starting after the first minute, resulting in the teams having a minute before the first order arrives to begin making what product they can in preparation for the orders.

After the push run is complete and the teams prepare for the next run, the pull run is begun, which disallows any production on a product before an order for that product is received, thus not allowing any preparation to occur. While the same number of products will be made during the five-minute run, the teams cannot anticipate the orders, causing them to only make products that have been ordered and not being able to prepare any products before the order is placed. The customer hands out an order every 1 minute and 15 seconds, starting immediately so that each team always has an order to be working on. Both runs consist of four orders of three products, resulting in 12 total Mr. Potato Head products being ordered and delivered in five minutes.

After the push and pull runs, each team is tasked with spending 15 minutes talking about and deciding on what changes they could make to improve consistency and quality of their products while reducing any unnecessary costs. Using the table of costs below (see Table 1), each student uses observations of successes and potential improvements they see from their role in the process to suggest changes to the process, while the ISEs coordinate with all team members to consolidate and agree on what changes would result in the maximum profitability. While the cost is reduced by removing workers or tables (saving teams $50 and $100 for each reduced respectively), teams risk additional mistakes being made which could result in higher costs than those saved in operating costs. As seen in this table, teams receive $200 for each unit correctly delivered, and charges range in value, reaching a maximum charge of $200 for each unit not delivered. Using this table, teams must weigh the most effective method for reducing cost while minimizing the expected charges occurred due to additional supplies or errors during production, ultimately maximizing their profit.

Table 1: Table of revenue and costs of Mr. Potato Head production

Item		Cost (per unit)
Operating Costs	Workers	(-$50)
	Tables	(-$100)
Invested Resources	WIP	(-$10)
	Finished Good	(-$20)
	Internal Defective Unit	(-$50)
Customer	Late Arrival	(-$25)
	External Defective Unit	(-$80)
	Wrong Unit	(-$75)
	Unit Not Delivered	(-$200)
	Unit Delivered	$200

Once the improvement cycle is finished, the final run is completed similar to the push run, where each order was given to the ISEs every 1 minute and 15 seconds, but teams are allowed to prepare products before receiving an order for that product. Once the run is completed, the total revenue and costs for each team are calculated using the data collected by the ISEs, final testers, and customers. The GTA asks each team what changes they made and how these changes resulted in an improved profitability. Using the final profitability of each team, the GTA also highlights which changes resulted in the most profitable run.

Deliverables

The Q&P lab is very activity-based, and data collection is not the students' primary focus throughout this lab's activity, but values recorded by students and UTAs described in the previous sections are compiled into a single spreadsheet that is made available to all students as a resource. Students are assigned a lab report to write in a four-member group within a week after completing the lab. Additionally, post-lab questions are provided for students to integrate into their lab report's results and discussion sections. The post-lab questions given to students are listed below.

1. What were the issues identified after run 1 (trial run)?
2. What further issues or difficulties were observed during runs 2 and 3?
3. Based on your observations/experiences from the first three runs, what changes were discussed, which of these were implemented in your final production line setup, and why were these changes selected?
4. After your improvement run (run 4), did your production team see increased profits? Why or why not? Describe changes made and how they affected costs, number of defective units, etc.
5. How did the pull run compare to the push run in effectiveness and profitability?
6. What role did communication play in the efficiency and profitability of your production team?
7. Based on your results, what manufacturing model would you recommend for the new Spuds Not Duds, Inc. production line? (NOTE: This does not necessarily have to be the final design your team used in run 4.)
8. If your team were to do a Six Sigma study on the quality of the Mr. Potato Heads being produced by Spuds Not Duds, Inc., what metric would you suggest be measured and improved?

This lab is particularly conducive to a group lab report because each student only held one role throughout the entirety of the lab and cannot speak as well to the experiences of other roles involved in the lab activity. By writing the lab report as a group of four students, lab report groups can be designed so there is diversity in the roles that they had in the lab activity, allowing the team to write the report from a more holistic perspective. In this lab report, students are asked to create tables of the costs of each production run, as well as note observations that they made throughout each production run.

Results

After each lab in the course, a post-lab survey was made available to all students to provide feedback on each lab. Using data from these surveys, the distributions of student answers available to us from the Fall 2019 semester are used to better understand the students' experience and select quotes from some students are used to emphasize the effects of the lab.

Enjoyment of the Lab

First, the students were asked if they enjoyed the lab on a Strongly Disagree to Strongly Agree scale. The results of this question are found in Table 2 below.

Table 2: Student responses to the statement "I enjoyed this lab."

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1%	0%	6%	36%	57%

As seen in this distribution, approximately 93% of students claimed to enjoy the lab. While none of the lab learning objectives relate to students enjoying the material, by making the lab more interesting and engaging, students may be more likely to participate in the lab and interact with the material, helping them to learn the material and accomplish the learning objectives of the lab.

The students were also asked how they envision the lab experience being useful to them in the future, allowing them to discuss their own thoughts on the lab. The responses of the students were read through and some quotes were picked to illustrate the thoughts that students had on the lab. In one response, a student noted that:

> *"I really enjoy making processes more efficient, so this lab has made me consider ISE. I made many effective recommendations for improvements that could be made for the final run, so this lab gave me confidence that I can understand and master lab material."*

This quote illustrates how introducing the content related to ISE in a fun and interactive way affected the student's consideration of the major.

Another student claimed:

> *"This lab was fun and was able to give an insight between the different manufacturing processes."*

This student related their positive experience in the lab with providing insight into the content of the lab. By creating a positive experience in lab, the introductory content of an ISE major was introduced effectively to the students, as seen from these quotes.

Learning of the Material

Next, the students were asked if they feel they learned a lot from the lab on a Strongly Disagree to Strongly Agree scale. The results of this question are found in Table 3 below.

Table 3: Student responses to the statement "I feel that I learned a lot from this lab."

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1%	4%	21%	56%	18%

As seen in this distribution, approximately 74% of students claimed they felt they learned a lot from the lab. This distribution shows that most of the students felt as though they gained significant learning from the lab. When asked how they envision the lab experience being useful to them in the future, one student noted:

> *"This lab was my first experience in ISE, and I enjoyed it. The six sigma method and lean manufacturing are both important for any engineering where manufacturing is involved. I believe knowledge of those two concepts will be*

useful in various projects in college, and later in on my career. They are just good skills to have."

This quote shows that the student believed that the lab content is important to any engineer working in manufacturing. Despite not having had an experience with ISE before this lab, the student can already see the use of the skills learned, emphasizing that they are good skills for any engineering student to have.

Another student noted that:

> *"In terms of content, there might not be much that I would use in the future, unless I delve into the industrial side of aerospace. If that were the case, it would be useful in optimizing any of the processes that occur during aerospace part manufacturing. In terms of the processes, optimization by itself is something that all engineers should be doing. Any process that an engineer does is often made to be more efficient through automation, whether that be through physical or digital automation. Efficiency is a major part of being a good engineer no matter the specialty."*

This student noted that while they may not use the specific content of the lab in the future, they relate the lab content to optimization, a skill they identify as being important for all engineers. While they do not anticipate all engineers to study manufacturing process, they believe any engineer could benefit from having studied optimization and envision how it could be used to improve other processes.

Additionally, another student noted:

> *"This lab provided me with the ability to look at a process critically and see where wasted time and money could be eliminated. This ability will come in handy when I am writing my own code or debugging someone else's."*

This student also realized that looking at processes critically and considering potential improvements is a skill useful to engineers. By relating this skill to the process of coding, they recognize that they are able to apply the skills practiced in this lab to other contexts. These quotes show how students felt that they learned a significant amount during the lab, understanding the skills to be useful not only to students studying ISE but to other students needing to improve other processes.

Clarity of the Lab

The students were also asked if the directions of the lab were clear on a Strongly Disagree to Strongly Agree scale. The results of this question are found in Table 4 on the following page.

Table 4: Student responses to the statement "The directions for this experiment (in-lab) were clear."

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
0%	1%	5%	55%	39%

As seen in this distribution, approximately 94% of students claimed that the directions of the lab were clear. When labs are designed and modified, it is important that the directions and explanations are clear so that the students can focus on the lab experience and developing their skills related to the lab.

Discussion

This lab experience was designed using the Mr. Potato Head toy for various advantages. First, the Mr. Potato Head toy may be more familiar to the students, requiring less time for students to become comfortable with the materials before being able to focus on the manufacturing process. The Mr. Potato Head is also easy to work with because of the small number of possible locations and orientations to place parts, and the differences in the various models make it easy to highlight the differences between the products because of the well-known shapes and parts of the toy (e.g. arms, feet, etc.). While other options like Legos or Bristle Blocks may be considered for this lab, they may require more building to produce a product that is recognizable or may make it harder to identify mistakes in the product. By creating variations of the Mr. Potato Head, students created an easily identifiable product that matched the scenario of the lab.

Some aspects of the procedure were designed to improve the experience of students and focus the lab on the key objectives. To understand the general process and what major roles are needed, the lab was designed to use teams of 12 students in 4 different roles, allowing each student experience in participating in their role on the team. Each role was designed to perform one simple task, keeping the complexity of the lab low so that students could focus on the desired objectives. Because each student experienced the lab differently due to the different roles, the group lab reports were used to allow a report team of four students to be created that contains different experiences through these different roles.

Additionally, the schedule of the lab was created so that four total number of runs were used. By including a trial run, students were given time to learn the general materials and processes used in lab without the expectation of understanding the whole process immediately to make changes. A push system and a pull system run were also used before the improvement run, allowing each student to participate in at least three runs and gain more experience with these manufacturing systems in the lab.

The lab learning objectives focus on the students' ability to identify elements of the manufacturing process and utilize the concepts of lean manufacturing and Six Sigma to improve the manufacturing process. To increase the awareness of the learning objectives, they were included on the course website, in the lab write-up, and discussed with the students during the lab. By focusing on the learning objectives, the students could better understand what skills they should be practicing in the lab (like utilizing lean manufacturing and Six Sigma) and what skills were not important for the course (like determining the differences between each product).

This lab was developed to increase student learning about introductory ISE topics, such as push and pull systems, lean manufacturing, and Six Sigma. Other labs in this course focus on topics related to other engineering majors, such as Chemical or Electrical Engineering, but these majors are typically easier to design a lab for first-year students than ISE. For example, chemical engineering labs can introduce students to the study of a fluid used in the lab, electrical engineering labs can be designed to let students practice building circuits and understanding how each component functions, but industrial systems engineering labs must carefully consider a design that incorporates the large-scale manufacturing of a product into a lab that students can complete in a classroom. By using the Mr. Potato Head with the lab design described, students can focus on these ISE topics and gain a better understanding of the major. A previous study highlights the usefulness for students to use simulations in learning engineering [8], thus to incorporate the benefits of hands-on learning into the lab, the students simulate a manufacturing process to better understand the reality of the scenario and the manufacturing process. Another study discusses the improvements to student learning through the use of team-based learning in engineering [9]. To incorporate these benefits into this lab, students were placed into large teams to complete the manufacturing of the Mr. Potato Heads and into smaller teams to complete a group lab report. While not all students plan to study ISE, all engineers can benefit from the experience of studying a problem and implementing changes to improve the solution while meeting given constraints.

Conclusion

In the honors track for the first-year engineering program at The Ohio State University, laboratories are utilized for students to both introduce them to engineering topics from various majors as well as develop their technical writing skills. This Quality & Productivity lab was designed to introduce first-year students to introductory ISE topics, reducing the size and complexity of a manufacturing process into a laboratory experience in a classroom. The lab uses Mr. Potato Head toys, allowing students to focus less on the complexity of the product and increase the emphasis on the manufacturing process and practice skills in evaluating and improving this process. With this design, students spend more time working with the process to practice it due to the small team sizes, simple team roles, and the four runs used to experience different types of manufacturing processes. The learning objectives of the lab focus on the ISE topics of the lab, directing students toward the skills important to learn from this experience. By adapting this lab to their own courses, other first-year engineering programs can successfully introduce students to industrial systems engineering through a positive and educational learning experience.

References

[1] B. M. Capobianco, H. A. Diefes-Dux, I. B. Mena, and J. Weller, “What is an Engineer? Implications of Elementary School Student Conceptions for Engineering Education,” *J. Eng. Educ.*, vol. 100, no. 2, pp. 304–328, 2011.

[2] K. P. Brannan and P. C. Wankat, “Survey of first-year programs,” in *4th ASEE/AaeE*

Global Colloquium on Engineering Education, 2005, p. 410.
[3] R. J. Freuler, A. W. Fentiman, J. T. Demel, R. J. Gustafson, and J. A. Merrill, "Developing and implementing hands-on laboratory exercises and design projects for first year engineering students," in *American Society for Engineering Education Annual Conference*, 2001.
[4] Ohio State University College of Engineering, "Annual Statistical Report," 2019.
[5] B. Morin, K. Kecskemety, K. Harper, and P. Clingan, "The Inverted Classroom in a First-Year Engineering Course," in *2013 ASEE Annual Confernce & Exposition Proceedings*, 2013.
[6] M. Kuhn and K. Vaught-Alexander, "Context for Writing in Engineering Curriculum," *J. Prof. Issues Eng. Educ. Pract.*, vol. 120, no. 4, pp. 392–400, 1994.
[7] S. A. Ambrose, M. W. Bridges, M. DiPietro, M. C. Lovett, and M. K. Norman, *How Learning Works: Seven Research-Based Principles for Smart Teaching*. John Wiley & Sons, 2010.
[8] L. Davidovitch, A. Parush, and A. Shtub, "Davidovitch, L., Parush, A., & Shtub, A. (2006). Simulation-based learning in engineering education: Performance and transfer in learning project management," *J. Eng. Educ.*, vol. 95, no. 4, pp. 289–299, 2006.
[9] V. Najdanovic-Visak, "Team-based learning for first year engineering students," *Educ. Chem. Eng.*, vol. 18, pp. 26–34, 2017.