An Integrated Platform of Active Learning Techniques in a Supply Chain Management Program

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Abstract

Active and experiential learning have gained much popularity in recent years, but their origins date back to long before the advent of formal schooling and books. From the beginning of time, humans have learned by doing, trying, and failing, until they found a solution. Wurdinger and Allison say this type of learning is a cognitive process, which must include planning, testing, and reflecting all in the same learning experience [1]. A number of such activities were integrated into an undergraduate supply chain management program. Firstly, four field trips were aligned with relevant subjects in the sequence of courses students took in each of the four semesters. For example, a field trip of a warehouse was scheduled in the semester when they took the Warehouse & Inventory Management course. Secondly, in the Quality Management course students took on various roles in a mock manufacturing company named Banchee, Inc. While making Banana & Cheese (i.e., Banchee) Cracker Sandwiches, they learned practical knowledge about the 5 phases in the DMAIC process. This was done in five, two hour sessions, each dedicated to a phase of DMAIC. Surveys revealed that students attributed higher levels of learning, retention, and comprehension of content, and they attached more excitement and worth to those courses that included active learning strategies.

Key words: Experiential Learning, Active Learning, Six Sigma DMAIC, Field Trip

Introduction and Background

An academic partnership with a university in a southern province in China resulted in the design and development of a new undergraduate 2 + 2 degree in supply chain management, which did not exist previously. Students in the program would study two years in China and the curriculum covered there would satisfy general education, English instruction, and program requirements such as math, economics, and basic computer and software skills. At the completion of the first two years, students would move to the United States for two years in residence to complete their degree. The curriculum for the two years completed in the US included major courses in supply chain management as well as supporting subjects such as accounting, marketing, and finance. The curriculum was offered in lockstep (cohort) format where all students enrolled in various sections of the same courses each term. The first cohort included 106 students.

Faculty who visited China in the first two years, reported that while some of the students had a reasonable command of the English language, a majority were not fluent or proficient. To address this concern, the decision was made to integrate experiential and active learning methods in the curriculum, to the extent possible. Learning through action; learning by doing; learning through experience; and learning through discovery and exploration are defined by several well-known and timeless maxims [2].

“I hear and I forget, I see and I remember, I do and I understand”	Confucius 450, BC
“Tell me and I forget, Teach me and I remember, Involve me and I will learn”	Ben Franklin 1750
“There is an intimate and necessary relation between the process of actual experience and education”	John Dewey 1938

To this end, various experiential learning activities and assignments were integrated into the program to make it more engaging for both the instructors and the students, and to also overcome some of the challenges that students faced in comprehending the material from a pure lecture-based instruction [3]. This paper discusses two types of experiential activities integrated into the curriculum: four field trips and a project-based laboratory to practice Six Sigma DMAIC methodology.

Field Trips Aligned with Course Sequence

McLoughlin asserts that for learning to occur, one must be engaged in the cognitive process to challenge oneself. She states that field trips can be a value-adding activity if planned and executed properly by the instructor so that the students are challenged before, during, and after the trip [4]. Four field trips were organized during the two-year period of the curriculum. Trips were lined up with the course sequence in the curriculum.

Effective field trips enable the learner to be an active participant in planning the activity and they build ownership and readiness of the students into the process [4]. One way to build ownership is to let students propose locations for field trips. Building readiness would be informing students of the location and providing them information about the facility. Both of these are good strategies to allow students to co-create parts of the curriculum and to help design their educational experience.

Since this student population was not well informed of relevant location choices available, in the spirit of building ownership and readiness, a week prior to each field trip students were given a flyer with information about the field-trip site, company history, products and services, number of employees, and description of the supply chain. They worked in groups to consider course topics relevant to the field trip. Each group generated a set of questions and shared them with other groups. Similar ideas were coalesced to consolidate and reduce the list. The final list of questions was distributed to all students so they could see in it their own contribution. This was helpful in making students feel a level of ownership in the field trip experience and be receptive to the travel and time spent on the trip.
On the day of the trip, students organized in groups of 10 -12 and led by a member of the host organization who guided the small groups. Students in each group asked the previously generated questions of the tour leaders and took notes to prepare a report of what they learned on the field trip.

1. Principles of Supply Chain Management and Logistics was an introductory course in the first semester that covered fundamental topics and information. For this topic, a field trip was organized to Gordman’s Retail Store and Disribution Center in the Greater Omaha area,

Nebraska. Students learned about electronic data interchange, bullwhip effect, reverse logistics, pricing and promotion, and other general concepts.

2. Warehouse and Inventory Management was paired with a field trip to Nebraska Furniture Mart Warehouse in Omaha, which is one of the largest furniture stores in the nation. Students learned about warehouse and space management, warehouse layout, inventory management practices, backordering, planned shortage, various inventory ratios, enterprise resource planning and role of IT in managing the warehouse, reverse logistics, sustainability and recycling, and similar topics.

3. A trip to Kawasaki Motors manufacturing facility in Lincoln, NE was aligned with the Business Systems Analytics and Operations Management course. Due to proprietary reasons, photography was forbidden inside the plant. On this field trip, students learned about such

topics as automation, plant layout, throughput and takt time, batch processing, production line change over and time, production scheduling for a family of products, and safety.

4. Finally, the course on Food Supply Chains and Sustainability resulted in a tour of Prairieland Dairy Farm which is a mechanized dairy farm near Lincoln, NE. Students learned about technology, automation, pricing, transporting and refrigeration of perishables, safety issues and restrictions imposed by governmental agencies such as the Food and Drug Administration and the Department of Agriculture. Recycling, composting, sustainability, and processing of animal waste were discussed, among other issues.

After each field-trip, students completed a report and responded to questions that were asked on the trip. The expectation was for them to relate their answers to concepts learned in class which were reinforced on the trip. The instructor(s) teaching the course with the subject most aligned with the trip had the responsibility of grading that assignment. To make this a manageable responsibility for the instructor, a rubric was used in grading the field-trip reports (Appendix 1).

Six Sigma DMAIC Labs

The curriculum included a course in Quality Management, which covered Six Sigma methodology and tools, lean thinking practices and tools, process mapping, and applications for business process improvement. Six Sigma is a method to reduce variation in business processes. DMAIC is a problem-solving technique integral to lean Six Sigma and focused on cost reduction by reducing variation and waste. In addition to the regularly-scheduled class times, the Quality Management course called for scheduling 10 clock-hours of laboratory dedicated to DMAIC methodology. Permission was granted by the College administration, and students were notified of the required lab component in the course. Students were assigned to five two-hour lab sessions.

The purpose of the labs was to help students internalize the DMAIC methodology of Six Sigma by applying the five phases of it in a practical application. DMAIC phases include: Define, Measure, Analyze, Improve, and Control. A previous study [5] utilized a cookie-baking activity to reinforce fundamental operations management topics. While DMAIC projects have many applications for solving a wide range of business problems, a common application is for reducing product defects in manufacturing industry [6]. The labs created a framework for a practical, hands-on application of DMAIC in a mock snack manufacturing facility, named BMC, where students acted as employees. To avoid medical complications due to nut allergy, instead of

Peanut Butter & Jelly sandwiches, BMC produced Banchee (Banana & Cheese) cracker sandwiches.

The DMAIC Labs allowed students to participate in a mock example of a Six Sigma project. Each student assumed a role in one of these functional areas: Management, Design/Engineering, Production, Quality, and Logistics. Members of those functions worked together to perform different tasks in each lab and collaborated to produce the deliverable(s) for each lab. The Quality role rotated each week so that by the end of Lab 5 everyone experienced the Quality role.

Quality characteristics monitored were specified by the customer (the instructor) and they included both variable and attribute data, including: thickness of banana slices, amount of cheese, weight & thickness of the sandwich, as well as attributes such as no crack in the cracker and no oozing of the cheese out of the sandwich**. Appendix 2** shows Lab instructions for all labs. **Appendix 3** shows the Product Specification Sheet.

An Excel file with more than 20 worksheets was provided for use during all five labs. A great deal of formulas, relationships, charts, and data values were entered in the file such as cost of the facility, indirect and direct labor, materials, machines, and waste. The file also provided templates for recording data, performing breakeven analysis, create SIPOC diagrams, process maps, create control charts, and perform capability analysis. Worksheets were linked for continuity of progress across all five Labs. After each lab, members of the group collaborated and entered the deliverable(s) for that lab into the Excel file for submission to the instructor. In the next lab, students would upload more deliverables to the same Excel file. In this manner, the entirety of the diagrams, data, and financial analysis was contained in the same file over the course of five weeks.

Supplies for the labs were inexpensive and provided by the school and at no cost to the students. Digital scales, rulers, measuring spoons, plastic spoons, plastic knives (to avoid cuts and injuries), bananas, square saltine crackers, liquid cheese cans and jars, and plastic gloves were the majority of the supplies used in the labs each week.

Lab 1 covered the Define phase. After about a 15 to 20 minute introduction to the work that they would be doing for the following 5 weeks, students engaged in the following activities:

- Created a SIPOC diagram (Suppliers-Inputs-Process-Outputs-Customers) to establish a broad overview of the process
- Reviewed a Product Specification Sheet provided by the customer
- Reviewed and discussed a Process Map for making Banchee
- Produced Banchee prototypes
- Measured and recorded quality characteristics
- Discussed sources of variation in the process.

In Lab 2 students learned about Measure phase of DMAIC and the importance of data to understand variation in the process. In this lab, they:

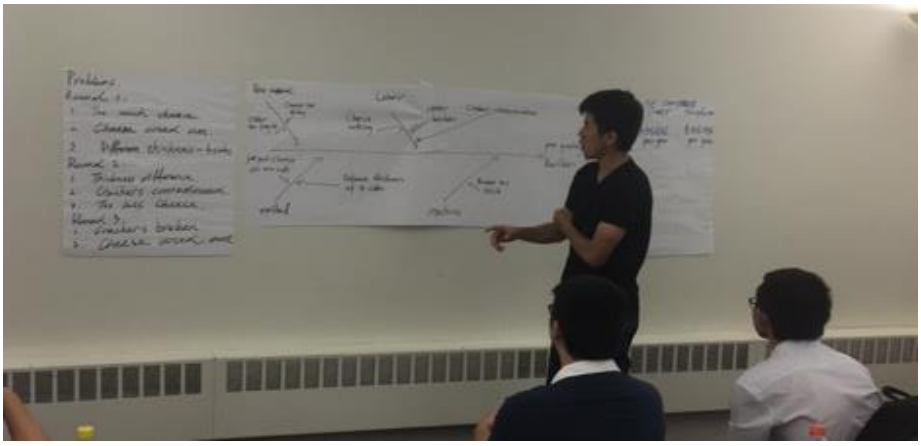
- Conducted 3 production runs of 10 minutes, each
- Took measurements on weight, thickness, other specs, delivery and cycle times
- Performed numerical MSA
- Updated financials and refined the Process Map based on Lab 2 activities

MSA in this phase resulted in important observations concerning variability in the shape of the whole fruit, and perishability of the fruit. Discoloration of banana that was too ripe made the fruit darker in color with brown spots, which in turn affected the visual appeal of the snack.

Additionally, bananas that were too ripe were softer in texture. This had a direct impact on handling and slicing of the fruit, with impact on variability in thickness. The soft texture also introduced a great deal of variability in the final product and the thickness of the Banchee because the softer fruit was more squishy and contributed to reduced thickness of the Banchees. Students noted increase in waste (in fruit, other materials, final Banchee products, and labor hours) and process variability.

In Lab 3, students learned about Analyze phase of DMAIC methodology:

- Performed MSA and analyzed results
- Added process cycle times to the Process Map
- Analyzed costs and brainstormed to find improvements: new methods, equipment
- Proposed process improvements
- Analyzed other options for raw materials and machinery



The Analyze phase is critical to generating improvement ideas based on the lessons learned in the first two phases. MSA in Lab 2 found manual slicing of the bananas was time consuming and introduced a great deal of variability in the production process. Students proposed purchase of slicing equipment for cutting bananas. This required management approval and an associated purchase cost, which went into financial calculations. This resulted in purchase of an additional lab item for the labs. A number of egg-slicers were purchased for students to use in Lab 4, to replicate and mimic the mass-slicing equipment and operation.

As discussed previously, Lab 2 revealed that the overall impact of using fresh fruit was increased waste and variability in the process. Students proposed using dry banana chips instead of fresh

fruit. This required negotiations with the customer (the faculty) to get permission for a change in the ingredients used in producing Banchees.

Once the customer approved, the next proposal was to purchase an industrial size dehydrator to dry the sliced bananas. This introduced new cost to enter into the financials. It also introduced the topic of batch processing because once operators sliced the bananas, they would have to wait for the fruit to dry in the machine before they could be used in assembling Banchees. As a result, new time measurements and cycle times had to be computed and impact on financials had to be considered. Data was included in the Excel sheet to account for using the dehydrator, processing times for drying fruit, and batch processing of Banchees.

In lab 4, students proposed improvements and reacted to associated changes. They ran new production runs with new methods and new equipment to identify potential for reducing production time, waste, and cost. They took new measurements and developed new production process maps based on proposed changes, and analyzed impact on the financials.

Finally, in Lab 5, students practiced the Control phase of DMAIC methodology. They did more production runs with improvements, collected and entered data into Excel file to create variable and attribute control charts, and reviewed financial analysis, and time and cost savings to determine if proposed changes were justified.

Findings and Summary

Four field trips were coordinated along the sequence of courses in which they enrolled. To provide a sense of ownership in co-creating their field trip experience, as a group students prepared questions that they would pose during the trips, and took notes. They prepared responses to those questions and the instructor of the course with the subject that was most closely related to the trip graded them using a rubric. While a survey was not distributed after each field trip, the graded assignment included two questions related to the field trip. Table 1 shows the mean response value (on a 5-point scale) to those questions. Please see **Appendix 4** for detailed summaries and percentage of responses to the five categories on the Likert Scale.

Table 1: Numerical Summaries for the Field Trips

The field trip helped to crystalize the topics I have studied in the book and learned in the classroom.		
Strongly Agree = 5 …… Strongly Disagree = 1	n	Mean
Store	102	3.25
Warehouse	103	3.19
Manufacturing	95	3.46
Dairy Farm	97	3.42
I enjoyed this field trip.		
Strongly Agree = 5 …… Strongly Disagree = 1	n	Mean
Store	102	3.96
Warehouse	103	3.33
Manufacturing	95	3.66
Dairy Farm	97	2.45

Due to various reasons, not all students were able to participate in the field trips. Therefore, the count (n) varies for each field trip. However, it is worth noting that response rate was 100% to these questions because every student who participated in a field trip submitted the assignment for that field trip, and as part of that assignment answered the two questions shown in Table 1. This means the data represents census; hence inferential statistics are not reported.

Mean response values were a little better than the mid-point on the scale and very close to each other for the four field trips. On the question which asked them if they enjoyed the trip, the visit to the Store received the highest marks. This was perhaps since that was the first trip they took and it was a novel experience. Additionally, this was a retail shop with plenty to items to touch and look. And, when the trip ended, the store manager gave all students a coupon for 30% off of one item, which also may have contributed for the better ratings given to that trip.

The Dairy Farm trip was about a 75 minute ride which required leaving campus very early in the day. Coupled with the fact that a dairy operation has odors that city-people can't tolerate, the visit to the dairy store was not the most popular of the four field trips. As a consolation, the dairy farm manager treated all visitors with ice cream! Responses to the first question about the dairy farm indicated that the students learned from that trip at about the same level as the other trips.

By the time students enrolled in Quality Management, four students had quit the program and gone back to China, so enrollment was at 102. Organizing and conducting the Labs was time consuming for faculty and an added responsibility since the labs took place outside of regularly scheduled class meeting times. Hence, it was desirable to determine whether the Labs were justified relative to perceived benefit they provided to students.

During the last week of class, students had the opportunity to complete a survey to reflect upon and share their opinions about the Labs and the Quality Management course. Responses were

measured on a Likert scale from 1 to 5, with 1 corresponding to Strongly Disagree, and 5 corresponding to Strongly Agree.

On the day when the survey was distributed in class, 98 (of 102) students were present and completed the survey. For this reason the highest count (n) reported is 98 in Table 2, which displays the questions and the mean value of responses on a 5-point scale. Some students did not respond to all questions (3, 4, 6, 8, 10, 11) which explains the lower counts (n). As shown in Table 2, with the exception of question 4 that had response rate of 88.2%, all other questions had response rates greater than 90%. In fact, questions 1, 2, 5, 7, and 9 claimed 96.1% response rate. Therefore, inferential tests were not performed since the data was effectively population data. Please see **Appendix 5** for detailed summaries and percentage of responses to the five categories on the Likert Scale.

Given that a score of 5 was a highly favorable response, Table 2 suggests that all in all students projected positive reaction to the Quality Management course and its five DMAIC Labs.

Table 2: Numerical Summaries for Lab Surveys

Likert Scale: 1 to 5 **5 = Strongly Agree ….. 1= Strongly Disagree**	**n**	**Response Rate (% of 102)**	**Mean**
1. The Lab activities made me think about what I read in the book	98	**96.1%**	**4.11**
2. The Labs helped me see the big picture	98	**96.1%**	**3.79**
3. The Labs helped my ability to confidently use DMAIC in the future	96	**94.1%**	**4.07**
4. Even after submitting the Lab report, I continued to think about what I had learned in the Lab	90	**88.2%**	**4.47**
5. I enjoyed this class more than other classes I am currently taking	98	**96.1%**	**4.33**
6. The Labs helped me learn concepts in a way that is not possible from only reading a book, which is what I must do in other courses	95	**93.1%**	**3.95**
7. I would take another course with Labs, if I could	98	**96.1%**	**4.23**
8. Personal interactions in the Labs with my instructor was valuable to me	97	**95.1%**	**3.61**
9. I remember DMAIC better than I remember other topics I studied in this class	98	**96.1%**	**4.78**
10. I learned more in this class than in other classes I took this term	95	**93.1%**	**4.34**
11. Relative to other courses I have taken so far at this university, this course is of more value to my education	92	**90.2%**	**3.85**

Killen states experiential activities used in educational research studies must benefit all students [7]. In the study under consideration, all students in the program benefited from the Labs, which strengthened their understanding of Six Sigma and DMAIC methodology. Mean response to

question 4 was nearly 4.5 on the 5-point scale. The question suggests that the cognitive impression the Labs made on the student was favorable and promoted mental review of the subject matter even after the activity was completed.

Closely related was the response to Question 9 which claimed an average score of 4.78 from the students, the highest among all questions. Students reported that among all topics they learned in the Quality Management course, they retained and remembered the DMAIC methodology the most. Since students practiced DMAIC in the Labs, it is natural they would rate this question highly.

Killen reports that experiential activities used in educational research studies must address the halo effect [7]. The halo effect is the pleasure or enjoyment a student gets from participating in study that might influence the student's perception of learning [8]. In the present study, the lowest average response was to question 8, at 3.61 on a 5-point scale. In this question, students indicated the degree to which they valued personal interactions with the instructor during Labs. While 3.61 is on the positive side of scale and a favorable outcome, these students did not believe strongly that the interactions with the instructor in the Labs and outside of class were valuable to them. It appears students did not assign much worth on building a rapport with the instructor during Labs and that halo effect was not present in this situation.

Question 2 was the other one with a low average response relative to the other questions. It is difficult to explain the result as one would think the intricacies practiced in the Labs would have provided the Big Picture. However, it is possible that the students' perspective was different in that actually producing the product, measuring quality characteristics, performing calculations, and the like is too detailed and focused; hence, the Big Picture perspective was not intuitively associated with the Labs.

Question 7 was to ascertain, indirectly and without being obvious, whether students liked taking a course with Labs. Average response was 4.23 to that question which shows that a majority of students had positive and satisfying experience in the Labs.

In summary, the survey indicated positive reception of the DMAIC Labs and integration of lab activities to course topic. Responses indicated enthusiasm for the active learning component, deeper learning, more cognitive engagement with the content, and satisfaction.

Lessons Learned and Reflections

The various experiential activities integrated into the pedagogical design of the undergraduate program were successful, received well by the students, and contributed to learning outcomes achievement. The approach and the activities are quite transferable and can be tweaked and modified to fit the requirements of other programs. To that end, the following are a few of the lessons learned and hindsight reflections.

1. The first couple of Labs resulted in a lot of paper. Each group used poster paper on the wall to document their discussions, process maps, and other diagrams. Soon the decision was made to add worksheets to the Excel file. This allowed all students in one group to access the diagram digitally and made the diagrams more accessible.

2. The five functions were too many. At times, although not too often, members of the logistics and management teams were idle. The recommendation is to only use 3 teams: Engineering & Design; Production & Supply Chain; Quality.
3. Only those playing Quality role rotated from lab to lab. It is recommended that each functions rotates regularly so all students are exposed to the activities and analysis that each function must perform.
4. Measurement of variable characteristics was frustrating at times. Devices used were not sensitive enough. It is difficult to use a digital scale or a ruler which is not all that accurate for monitoring specification given by customer. If cost is prohibitive to acquiring more appropriate tools for measurement, perhaps random number generators with upper and lower bounds could be used to generate production data.
5. Require each team (made up of various functions) to present their findings at the end of Lab 5. This was scheduled to occur in the classroom (not in the Lab). However, due to lack of time during class, the oral presentations did not take place.
6. Students and instructors enjoyed the Lab and looked forward to them. But, the setting up of the labs and clean-up afterwards was time consuming, even though students would often help, if they were not running late for another class.
7. Related to above item, request TA to help with setup, clean-up, and help during Labs.
8. Provide the Excel file to students early on and take time to walk them through the worksheets. Emphasize that they must use it to populate with Lab deliverable(s).
9. Due to the unrealistic and small size of work space and short lab-times and production run times, assumptions were made. For example, every inch on the table between Production and Engineering departments was assumed to be X yards. Or, each minute of production was equivalent to Y days. These assumptions were not clearly documented in Lab 1. They must be provided prior to the first lab.
10. In the dress code instructions for the dairy farm, clearly specify that the soil would be wet and muddy. Do not wear fancy and expensive shoes on this field trip.

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Appendix 1: Field-trip Report Grading Rubric

	Poor	**Fair**	**Good**	
Response to Questions	< 60% questions answered (0 to 1)	60% - 80% questions answered. (1 to 2)	> 80% questions answered (2 to 3)	3
Concepts Learned	< 2 concepts used. Description is poor. (0 to 1)	2 – 3 concepts are listed and described well (1 to 2.5)	>3 concepts are listed & described with detail (2.5 to 4)	4
Stylistic (Proper use of English to convey meaning)	Obvious grammatical or stylistic errors make understanding difficult (0 to 1)	Several grammatical or stylistic errors interfere with content (1 to 2)	Few to no grammatical or stylistic errors. Hence work is easy to read and comprehend. (2 to 3)	3
				10

Appendix 2: Instructions for Lab 1 - 5

Lab 1 – Define

1. Costs: Factory, labor, delivery, machines, raw material, cost of waste (estimates built into the Excel template)
2. Divide into groups and take measuring devices (calipers, scales) and supplies

   Assign positions:

   - Manager – Financials and lab report - 1
   - Quality – Measurements - 3
   - Production – produce the Banchee - 2
   - Logistics – raw materials, transport, purchasing -2
   - Design/Engineering - 2
3. Determine Revenue per Banchee from customer
4. Define the problem
5. Deliverables:
   A. Charter- Project Charter (1).doc or begin A-3
   B. SIPOC – in lab spreadsheet
   C. Specifications of product- Product Specification Sheet.doc
   D. Review Process Map – In spreadsheet
   E. Review Customer Specs – Product Specification Sheet.doc
   F. Produce first Banchees – make 10
   G. Get first measurement
      a. Weight
      b. Size – thickness
      c. Conformance to specs

H. Quality people do 1st MSA – do an attribute MSA

Lab 2 – Measure

1. Run 10 minute production – 3 times
2. Take measurements
    a. Weight
    b. Thickness
    c. Other specs
    d. Factory measurements
    e. Delivery time
    f. Cycle times
3. MSA – Quality and Engineering – Numerical MSA – new quality people
4. Update financials for Management and Design/Engineering
5. Requirement for inventory control. EOQ, EPL model
6. Refine Process Map – More detail

Lab 3 – Analyze

1. MSA – Do MSA - Analyze results – new quality people
2. Add the process cycle times to the process map
3. Brain storm to find improvements analyze the costs – evaluate new methods & equipment
4. Develop improvements to the process
5. Analyze the position of the company due to the financials
6. Analyze other options for raw materials. Machinery
7. Deliverable is recommendations

Lab 4 – Improvement

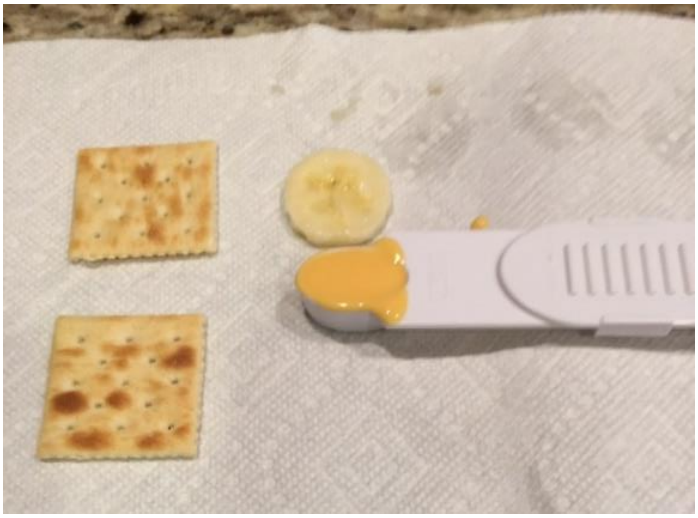
1. Run production runs with new methods, improvements,
2. Take new measurements,
3. Do MSA – new Quality people.
4. Develop new production process map with improvements
5. Analyze the impact on the financials

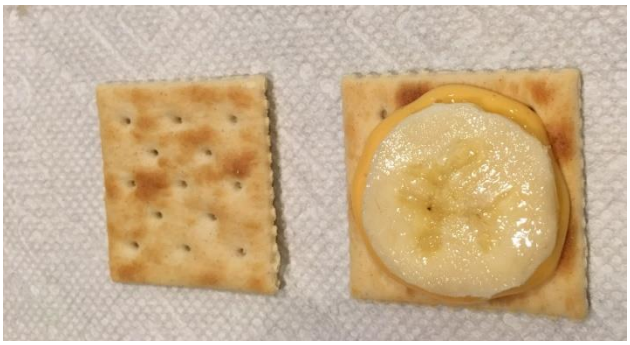
Lab 5 – Control

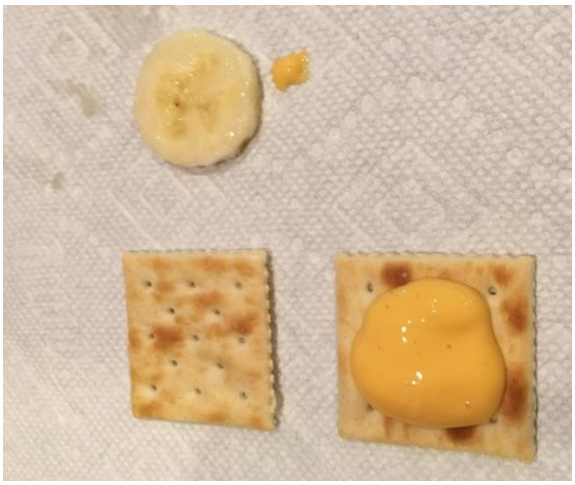
1. Develop control charts for the production runs
2. Last group of MSA measurements and training
3. Run production and collect data to put into the control charts
4. Special/common cause inputs and outputs
5. Summarize the learnings from all the labs.

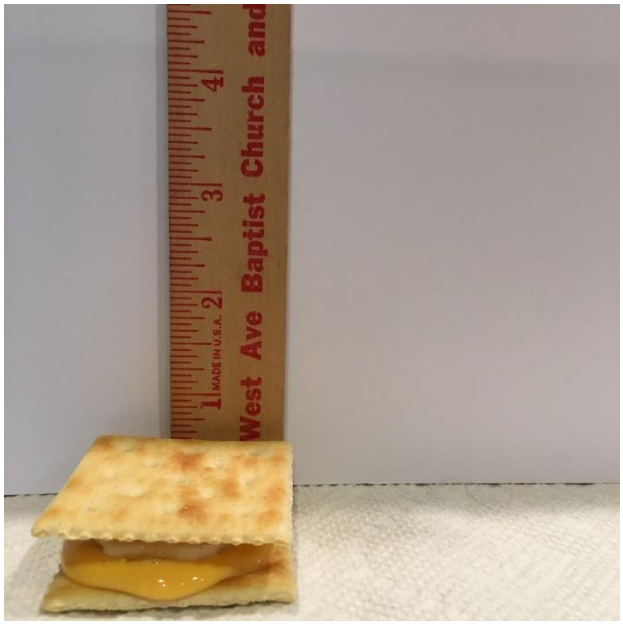
Appendix 3: Product Specification Sheet for Banchee

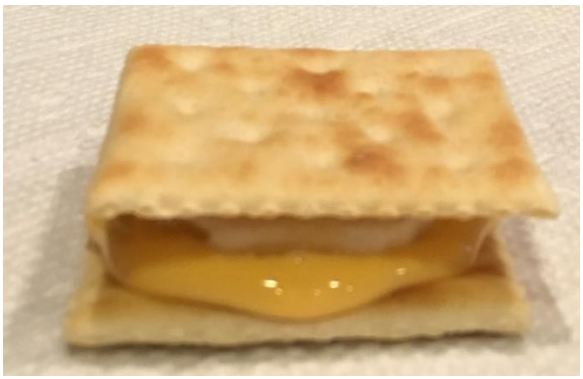
- ✓ Target Banchee Thickness - .5 inch +/- 0.05
- ✓ Target weight – 0.50 oz +/- .05
- ✓ .25“ +/- .05 margin of cheese on cracker
- ✓ No cheese oozing from the side of the cracker
- ✓ Banana thickness 0.125 inch +/- .005 slice
- ✓ Banana diameter must be 1” +/- 0.125”
- ✓ Package 4 Banchees in a package.
- ✓ Ship directly to the customer in batches of 4 packages.











Appendix 4: Detailed Summaries for Field Trip Questions

Likert Scale: 1 to 5 **5 = Strongly Agree …. 1 = Strongly Disagree**	**n**	**Mean**	**Mode**	**Median**	**Min**	**Max**
The field trip helped to crystalize the topics I have studied in the book and learned in the classroom.						
Store	102	3.26	3	3	1	5
Warehouse	103	3.19	2, 4	3	1	5
Manufacturing	95	3.46	3	3	1	5
Dairy Farm	97	3.42	3	3	1	5
I enjoyed this field trip.						
Store	102	3.96	5	4	1	5
Warehouse	103	3.33	3	3	1	5
Manufacturing	95	3.66	5	4	1	5
Dairy Farm	97	2.45	1	2	1	5
The field trip helped to crystalize the topics I have studied in the book and learned in the classroom.						
Likert Scale: 1 to 5 5=Strongly Agree ….. 1 = Strongly Disagree	n	SA 5	4	3	2	SD 1
Store	102	18%	25%	30%	18%	9%
Warehouse	103	20%	27%	15%	27%	11%
Manufacturing	95	20%	25%	37%	17%	1%
Dairy Farm	97	21%	25%	39%	7%	8%
I enjoyed this field trip.						
Likert Scale: 1 to 5 5=Strongly Agree ….. 1 = Strongly Disagree	n	SA 5	4	3	2	SD 1
Store	102	37%	32%	22%	7%	2%
Warehouse	103	24%	20%	31%	13%	12%
Manufacturing	95	33%	29%	18%	12%	8%
Dairy Farm	97	10%	13%	19%	27%	31%

Appendix 5: Detailed Summaries for DMAIC Labs Survey

Lab Survey: Descriptive Numerical Summaries

Likert Scale: 1 to 5 **5 = Strongly Agree ….. 1 = Strongly Disagree**	**n**	**Mean**	**Mode**	**Median**	**Min**	**Max**
1. The Lab activities made me think about what I read in the book	98	**4.11**	5	4	1	5
2. The Labs helped me see the big picture	98	**3.79**	4	4	1	5
3. The Labs helped my ability to confidently use DMAIC in the future	96	**4.07**	5	4	1	5
4. Even after submitting the Lab report, I continued to think about what I had learned in the Lab	90	**4.47**	5	5	1	5

5. I enjoyed this class more than other classes I am currently taking	98	**4.33**	5	5	1	5
6. The Labs helped me learn concepts in a way that is not possible from only reading a book, which is what I must do in other courses	95	**3.95**	4	4	1	5
7. I would take another course with Labs, if I could	98	**4.23**	5	4	1	5
8. Personal interactions in the Labs with my instructor was valuable to me	97	**3.61**	3	3	2	5
9. I remember DMAIC better than I remember other topics I studied in this class	98	**4.78**	5	5	4	5
10. I learned more in this class than in other classes I took this term	95	**4.34**	5	4	3	5
11. Relative to other courses I have taken so far at this university, this course is of more value to my education	92	**3.85**	4	4	2	5

Lab Surveys: Percentage of Responses on Likert Scale

Likert Scale: 1 to 5 **5=Strongly Agree ….. 1 = Strongly Disagree**	**n**	**SA** **5**	**4**	**3**	**2**	**SD** **1**
1. The Lab activities made me think about what I read in the book	98	48%	32%	12%	5%	3%
2. The Labs helped me see the big picture	98	24%	34%	28%	12%	2%
3. The Labs helped my ability to confidently use DMAIC in the future	96	45%	31%	11%	11%	1%
4. Even after submitting the Lab report, I continued to think about what I had learned in the Lab	90	67%	16%	17%	0%	1%
5. I enjoyed this class more than other classes I am currently taking	98	55%	29%	13%	2%	1%
6. The Labs helped me learn concepts in a way that is not possible from only reading a book, which is what I must do in other courses	95	33%	40%	22%	3%	2%
7. I would take another course with Labs, if I could	98	44%	38%	17%	0%	1%
8. Personal interactions in the Labs with my instructor was valuable to me	97	20%	28%	51%	2%	0%
9. I remember DMAIC better than I remember other topics I studied in this class	98	78%	22%	0%	0%	0%
10. I learned more in this class than in other classes I took this term	95	53%	28%	19%	0%	0%
11. Relative to other courses I have taken so far at this university, this course is of more value to my education	92	25%	45%	27%	3%	0%