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Integrating Entrepreneurially Minded and Project-Based Learning into a Manufacturing Supply Chain Course

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Abstract

Project-based teaching fosters student-centered learning, allowing to cater to alternative student learning styles and to accommodate heterogeneous student communities. However, fewer and fewer of the courses that we offer incorporate a term project as one of the main requirements for assessment and evaluation. This investigation aims to evaluate, from a student learning perspective, the benefits of incorporating interdisciplinary entrepreneurially-minded and project-based learning into a required Manufacturing Information Management course in Drexel University (DU) Engineering Technology curricula. The benefits are assessed based on Photovoice reflections as well as written and oral presentations during and at the end of the term and are based on evaluating the level of practical knowledge gained by the students during the development of such projects. As a general outcome, students became more involved during class time, and also they have shown interest in other research areas, being involved in extra course research activities. Details related to the intervention and lessons learned will be provided so other engineering instructors can easily re-create in the classroom. Overall, many different fields of engineering instructors can benefit from this project-based approach to combine theory and practice to prepare the students to become better problem solvers and obtain practical solutions to real-life/simulated problems using a project-based approach.

1.1 Introduction

As our courses geared towards incorporating new technological trends in supply chain management and sustainability, the capstone senior design project topics in this area also increased. The main aspects presented are related to the integrative approach in green energy harvesting, manufacturing, and sustainability, serving as models of energy efficiency and sustainable supply chain management, with a clear assessment of student-led projects developed during past academic years and how they contributed directly to the development of leadership skills along with untamed creativity. These capstone projects, along with clear connections between projects and curriculum development, are described, underlining the interdisciplinary nature that simulates real-world situations and integrates sustainability with creativity and innovation [1][2]. Capstone projects developed in the past five years by our students are the corollary of their educational journey and also an excellent assessment of their level of skills and competencies acquired during this journey. Manufacturing and energy, and sustainability capture more than 65% of the capstone topics chosen by our students. These projects provide a great opportunity to experience and overcome the uncertainties inherent to all engineering projects. Projects are open-ended—having a spectrum of possible solutions; students are ultimately responsible in deciding which solution to pursue.

The main focus of the project mimicking the capstone project would be to embed and integrate Entrepreneurially Minded and Project-Based Learning into a Manufacturing Supply Chain Course used in both Industrial Engineering Technology and Mechanical Engineering Technology curricula. This approach will combine the skills necessary to succeed in today's engineering business world: engineering concepts, a sustainable focus, team skills, and multi-attribute decision-making and problem-solving skills. Students will learn to think globally by addressing the larger-scale supply chain issues currently faced in manufacturing supply chain networks and propose potential solutions to these challenges. Decisions can be made both independently and in a group setting, thus enabling students to develop collaborative decision-making and problem-solving skills. Thus this course development has the following objectives: (1) Integrate sustainability concepts within the framework of the Industrial & Mechanical Engineering Technology curriculum and emphasize the dichotomy which exists between sustainable and economic-based decisions; (2) Embed decision-making approaches within a student-led team environment; (3) Enable students to make decisions under uncertainty with open-ended what if scenarios simulating a real-world situation – integrate sustainability with creativity and innovation.

1.2 Problem Identification

The following problems in the ET curriculum were identified by several faculty:

- Not enough real-world projects in the engineering classroom.
- Limited approaches to connect theory and practice

In addition to above problematic areas, during several SWOT analysis sessions of the Engineering Technology curriculum, conducted with Engineering Technology Curriculum Committee members and ET faculty plenum, several curricular and competencies gaps have been identified. The gaps related to this investigation are as follows:

a) Students' ability to formulate clear problem statements and to select solutions to meet specifications is poor.
b) Students' lack the sufficient depth of understanding in upper-level courses.
c) Students' ability to communicate and justify engineering decisions is poor.

Students in the Mechanical, Electrical, and Industrial fields along with many others can learn many new skills from multi-disciplinary projects such as this one combining theory and practice to prepare the students to become better problem solvers and obtain practical solutions to real life/simulated problems using a project-based approach. Such projects show students how to define a problem and demonstrate how available and advanced technologies can be used in an innovative supply chain design improvement. Overall, many different fields of engineering can benefit from this problem-based approach, enabling the development of skill and knowledge in many different engineering aspects and processes. This mini supply chain design project stimulates the students' interest in real-world problem solving via eliminating waste in supply chains and as well as proposing lean operations.

1.3 Current Approaches and Identified Gaps

- NAE Grand Challenges: this investigation relates several categories such as improved methods of instruction and learning including ways to tailor the mind's growth to its owner's propensities and abilities [5]
- Co-ops and internships gaps
  Limited standards and consistencies; limited to 1-3 experiences at DU. Co-op represents a practical evaluation of what students had learned and if the knowledge that was provided satisfies industry needs. In DUs ET program, students can choose 3 Co-op Cycles (5 year) or 1 Co-op Cycle (4 year) during Bachelor of Science degree programs in Engineering Technology. This project will fill especially gaps in the 1 co-op option.
- Capstone/Freshman gap: Design experiences limited to freshman design and senior design; this mini project will provide much needed intermediate design focus and less technical integration.

1.4 Proposed Solution

In order to help closing gaps identified in 1.2, the author proposes an Interdisciplinary mini-capstone research project to provide real-world experiential learning to better prepare engineering students for entering the workforce. This project fuses Enterpreneurship Mindset along with STEAM (Science-Technology-Engineering-Art-Mathematics) and Biology/sustainability aspects to students thinking in terms of problem identification and proposing relevant solutions to the supply chain issues currently faced in manufacturing industries.

2.1 Background / Literature Review

As presented in the Manufacturing Annual Report for FY 2016, "American manufacturers contributed $2.18 trillion to the U.S. economy in 2016"[3]. However, the deficit in advanced manufacturing is about $90 billion. This calls for an increased pace of job creation on American soil, in manufacturing industry allowing us to continue to research and invent. Educational institutions have a mission to develop game-changing technology and the skills needed to equip our future U.S. manufacturing workforce (Manufacturing USA Annual Report FY2016, 2017).

It is well recognized that manufacturing plays a critical role in the American economy, underpins U.S. innovation, and is essential to national security. Numerous factors—private and public—shape the

competitiveness and innovation's performance of U.S. manufacturing. Smart manufacturing, the use of real-time data and technology that are needed to meet the changing demands in manufacturing industries, is predicted to be the next industrial revolution. (Lu et al., 2016) With emerging trends opening up new areas of innovation to optimize the manufacturing fields, there is an ever-increased need of future skilled workforce that adheres to emerging manufacturing technologies. These skills need to be developed and applied in engineering and engineering technology education (Smart Manufacturing, Jim Davis et al., 2012 [4]). According to Deloitte and Manufacturing Institute, there will be a skilled workforce deficit of about 2 million jobs during the next decade.

2.2 Interdisciplinary Mini-Capstone Research Project

The proposed Mini-Capstone Research aims to enhancing student participation by introducing STEM aspects of technology education via student photovoice aseessment, and inclusive learning environment for student development. The goal and objectives are set so that the proposes project activity not only helps developing the STEAM workforce but also enhances important learning skills such as critical thinking, explanatory knowledge, problem-solving when students are exposed to the real world open ended problems. The emphasis of this project is on the applied aspects of the technological spectrum, such as process improvement, looking industrial practices with the emphasis of Entereperenrship Mindset, and sustainable supply chain operations. The overview of the Value System Mapping provided within the course is aimed at supporting this emphasis in the mini term project.

3. Methods

3.1 Study Design

Term Project Summary:

Supply chains (SCs) are complex systems that encompass many activities that industrial/manufacturing engineers can solve. This study examines a term project where students were asked to develop a simple, creative, yet fun cartoons to illustrate current and relevant supply chain challenges. Additionally, they created value stream maps (VSM) to illustrate how these challenges can be solved by looking into various industries (Automotive, aerospace, apparel, electronics, etc.), products and businesses. Students will be investigating and identifying what new business ideas these challenges will be (or currently) generating. Students were asked to identify sustainable practices and processes during their VSM mapping. At the end of the term, there was a team competition based on the deliverables of the project. In the competition, students presented their cartoon(s) and VSMs that helps to illustrate some of the challenges SC designers and users face. Student teams will also suggest up to three possible captions in to accompany each cartoon. Sample student submitted VSM charts and Cartoons can be find in Appendix B.

Project Description

A process map documents how work either is, or should be, accomplished, and how the transformation process creates value. Studnts, acting as SC designers, first developed a "baseline" map of how the current process operates to understand it and identify improvements for a redesign. In service applications, flowcharts generally highlight the points of contact with the customer and are often called service blueprints or service maps.

In conducting this project, students learn that such flowcharts often show the separation between the back office and the front office with a "line of customer visibility." A VSM shows the process flows like an ordinary process map; however, the difference lies in that value stream maps highlight value-added versus nonvalue- added activities and include costs associated with work activities for both value-added and non-value-added activities.

Learning Objectives

By the end of this term project assignment, students will be able to:

a. Describe how to apply process and value stream mapping for product/process design.
b. Define the purpose and objectives of the product that will be aimed for the supply chain.
c. Create a detailed process/product value stream map that describes how the supply chain is currently performed.
d. Create cartoon(s) to illustrate current and relevant supply chain challenges for the chosen product.
e. Identify and define appropriate performance measures for the supply chain.
f. Evaluate alternative process/ supply chain designs within the supply chain that will reduce waste and create more sustainable supply chain for the chosen product.
g. Identify and define new potential business opportunity (es) that can be generated by the improved supply chain.
h. Define and select the appropriate equipment and technology for the supply chain.
i. Develop an implementation plan to introduce the new or revised supplied chain including newly proposed process design (s).
j. Present challenge cartoons (team competition) and before and after VSMs for the supply chain with the emphasis on waste reduction and sustainability of the supply chain.

3.2 Participants

This course title used in this investigation is Manufacturing Information Management. It is a three-credit hour required course taken by Industrial Engineering Technology and Mechanical and Manufacturing Engineering Technology junior or senior level undergraduate students. It covers information management in manufacturing and include topics such as cost estimation and control, manufacturing resources planning (MRP), just-in-time (JIT), production and inventory controls, management information systems (MIS), supply chain management (SCM), and other advanced information management technology. Currently there are twenty-two students taking the course with 23% being female student.

3.3 Data Collection

Data were collected using PhotoVoice metacognitive assessment [8, 9, 10] and open ended-reflective questions. Three PhotoVoice prompts and three open-ended prompts were used; students submitted responses online through BlackBoard LMS (please see Appendix B for a sample PhotoVoice metacognitive Asssesment). The prompts used in this study are listed below.

Photovoice Reflection Prompt A (Entrepreneurial Mindset): The entrepreneurial mindset is defined as "the inclination to discover, evaluate, and exploit opportunities." Explain how participating in the newly developed curriculum incorporated the entrepreneurial mindset, and lessons learned relevant to the entrepreneurial mindset.

Photovoice Reflection Prompt B (STEAM): STEAM (science, technology, engineering, arts, math) goes one step beyond the well-known STEM to acknowledge the importance of integrating the arts and humanities into more analytical coursework such as that found within engineering. Art can be incorporated through pieces, process, and movements. Explain how participating in the newly developed curriculum incorporated STEAM (specifically, the arts), and lessons learned relevant to STEAM (specifically, the arts).

Photovoice Reflection Prompt C (Bio-Inspired Design): Bio-inspired design uses the nature-focused context of sustainability, security, and/or biomedicine and health outcomes to motivate analogical thinking and improve the engineering design process. Explain how participating in the newly developed curriculum incorporated bio-inspired design and lessons learned relevant to bio-inspired design.

Open-Ended Reflection Question A (Interdisciplinarity): The interdisciplinary approach of integrating the entrepreneurial mindset, STEAM (specifically, the arts), and bio-inspired design has been shown to improve student engagement, motivation and learning outcomes. How did this interdisciplinary learning experience affect your ability to engage with the newly developed curriculum?

Open-Ended Reflection Question B (Debrief): What went well? What didn't go so well? What will you do differently next time?

Open-Ended Reflection Question C (Connect to Real World): What skills did you learn? Please consider both professional skills (e.g., communication, collaboration, etc…) and context specific skills (e.g., topic area). Why are these skills important for engineers in the real world?

3.4 Data Analysis

This study followed a qualitative approach using thematic analysis. According to Braun and Clarke (2006), a thematic analysis is a foundational qualitative method for discovering patterns within the data. It should be conducted using a step-by-step process. The author first became thoroughly familiar with the data to generate initial codes using NVivo12 qualitative analysis software (Figure 1). Upon the completion of coding, themes were generated. As a final step, the author revised the themes and wrote the report. The author debated the strengths and weaknesses between strictly conceptualizing themes without quotes and heavily using quotes to provide readers with evidence. It was decided to merge the two philosophies and meet in the middle. Quotes were drawn from the data to allow readers to make their own judgements on credibility, accuracy, and fairness [11].

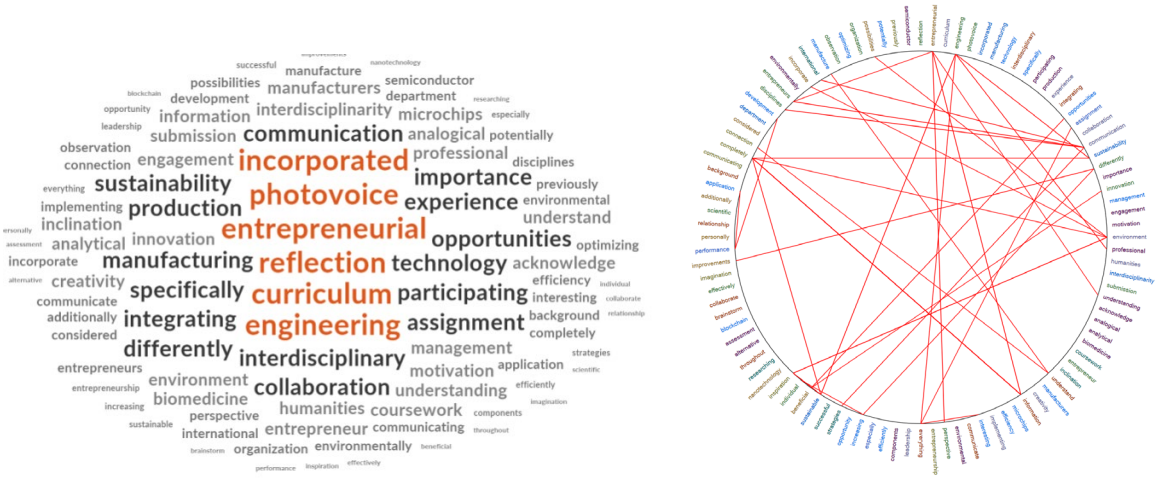

Figure 1. Word Query result using Nvivo: 1000 most frequently used words with minimum length of ten.

3.5 Deductive Thematic Analysis

Deductive thematic analysis was conducted by applying the conceptualization of motivation to learn resulting from three factors: self-efficacy, seeing value, and a supportive environment [3, 4]

Self-efficacy describes one's confidence in the ability to complete a performance-based task. Several participants emphasized an increase in self-efficacy by referencing skill development, and by responding with a capacity to apply new tools and strategies. Example quotes are provided here:

- The PhotoVoice did bring a nice mix of image, essay, and engineering. **I will use this in all my research projects**."
- "PhotoVoice is a **great new assessment tool for me**."
- "It also helped me to **feel more confident in searching** through and creating VSM charts."

- "I **learned how to** incorporate art into my engineering project.

Seeing value describes one's recognition of purpose related to the performance-based task. Students underscored newly gained perspectives in seeing value by acknowledging a desire to apply the skill development in the future and commenting on the effectiveness and usefulness of learning gains. Example quotes are provided here:

- I have very limited training in the art creation but see many connections across design. Students did not find this part of the process scary and seemed to really enjoy it.
- "Different methods for peer feedback and classroom interaction were introduced through written and oral presentations were very valuable for the students.
- "Students were interested in expanding to other engineering technology project courses."

A supportive environment describes one's perception of and access to a broader environmental context. The environment can be viewed from multiple lenses including personal home environment, instruction style, institutional support technology, and community factors, to name a few. Several student participants commented on the effectiveness of environmental factors by highlighting support provided by peers and instructor feedback. Example quotes are provided here:

- "Getting **real-time advice** on ideation, and brainstorming [was helpful].
- "**Connection with peers** doing incredible work and involving aspects of this program in unexpected and exciting ways."
- "Implementation of the skills **with help of mentors** was a benefit."
- "**Peer interaction** helped me to see how other people went through a similar process."

3.6 Course Evaluation:

Prior to finishing the MET408- Manufacturing Information Management course, students filled out evaluation surveys using Drexel's Academic Evaluation, Feedback and Intervention System (AEFIS). Based on this evaluation system the overall course rating was 3.75 out of 5.0 (maximum scale).

The best aspects of this course, as perceived by students can be summarized as follows:

They were highly satisfied by the opportunity provided by the project to be creative and to be able to do research on the topics that they were interesed. Quoting of several of the student reviews are provided below:

"The best aspects of this course was the lecture content and how it directly related to industry. I was able to clearly visualize certain concepts and how it ties with what industry professionals do. We were not just learning textbook stuff. The course instructor really connected textbook material with "real life" material and experiences."

What specific, practical changes can you recommend that might improve this course?

"To improve the course, I would either add more short papers in place of some homeworks because the midterm and final report we had to do, I felt that that was more beneficial in the aspect that we the students get to research topics which we are interested in relating to the class."

"I thought that the pace and workload was good compared to other classes."

Overall course assessment and course survey questions relevant to this paper and term project are provided in Figure 1 and 2 below.

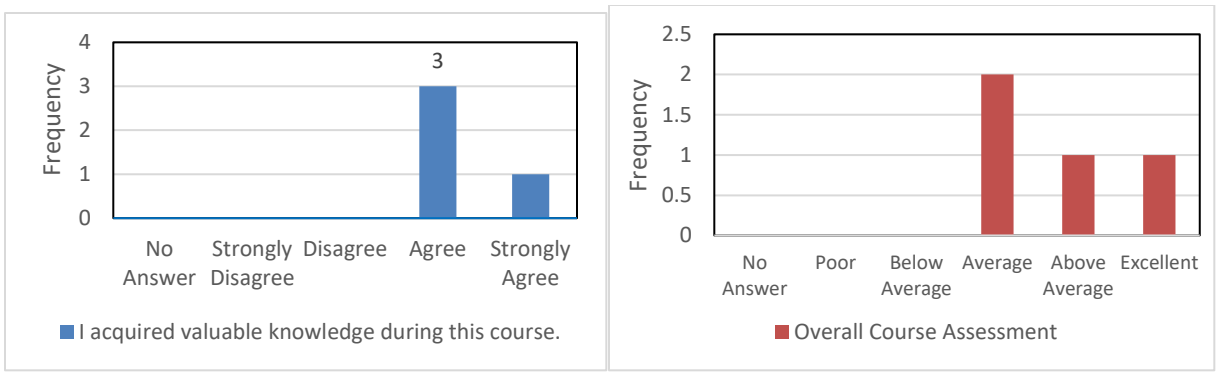

Figure2. AEFIS Course survey response.

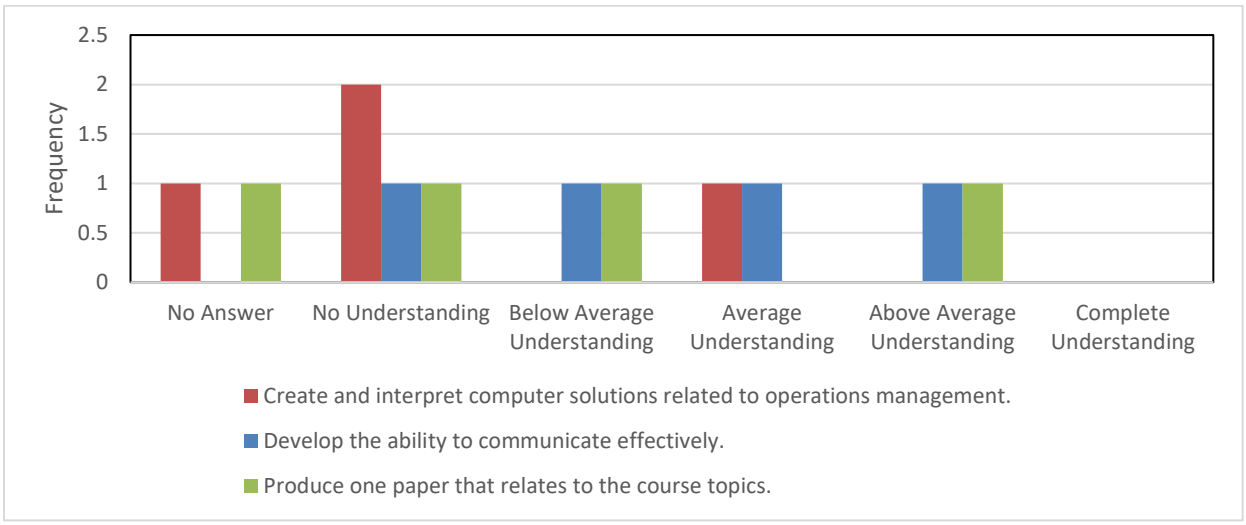

Figure 3. AEFIS Course survey response before entering course.

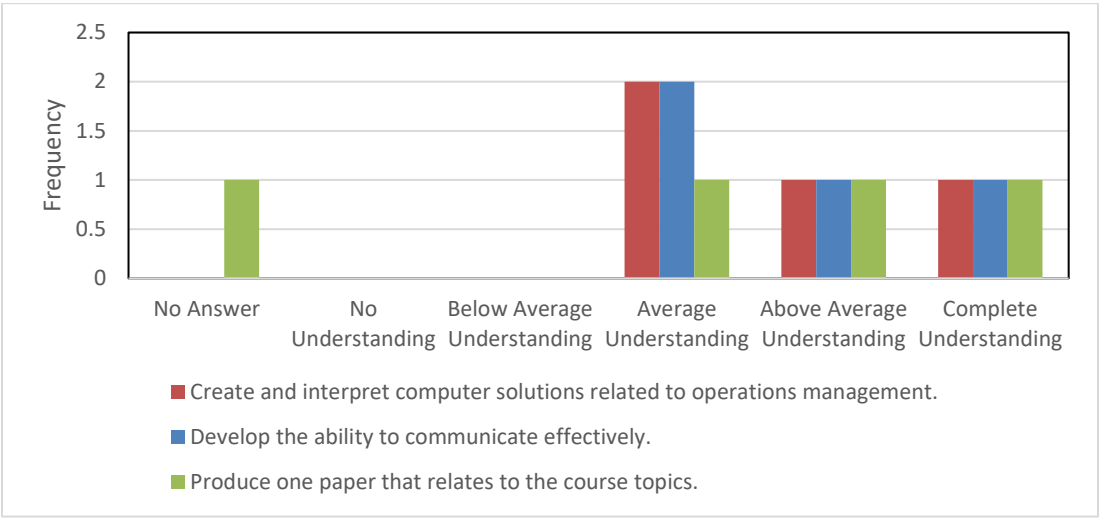

Figure 4. AEFIS Course survey response after taking course.

Figures 3 and 4 summarize AEFIS surveys in regard the course objectives most closely related to the term project in this investigation. Students self assessment reflects that t there is a positive impact in terms of

finding solutions to the problems and communicate it to the peers more effectively after completing the course work and required mini term project.

4. Discussion

Research has demonstrated the use of online formative student assessment, such as term project interim reports and presentations, can be particularly effective in STEM education courses. Furthermore, Photovoice metacognitive assessments have been useful in gaining, refocusing, and extending student attention during lectures. In terms of summative student assessment which includes final exams or course projects with written and oral presentations, same principles and strategies may be incorporated with continuous clarification of instructions and expectations from the instructor.

Imbedded into the course development phase of this project and the "optimization" of student learning, course development specialists (i.e., faculty or instructors with subject-matter expertise) will also pay close attention to the incorporation of "best practices" and principles. As described by Miller (2014), course development may include, but is not limited to, six general principles: student-to-student interactions, active student engagement in learning, emphasis on practice and student effort, learner-centered or personalization of subject-matter, variety of presentation modalities, and emphasis on higher thinking skills and processes via authentic assessment approaches with focus on real world application and problem-solving opportunities.

For each supply chain course developed and delivered to enrolled students, ongoing and scheduled formative assessments during the semester can be implemented in addition to a "culminating event" per course that provides evidence of students gaining competency levels in content and skills. Main questions to consider in the assessment of learned material and skills include: how will assessments take advantage of the testing effect? Tests are highly effective at promoting retention of studied material; How will assessments function to motivate, not demotivate students? Students' experiences with projects and project feedback provide a powerful means for shaping a mindset of growth, including enhancing student academic self-efficacy. In combination, these principles applied to real life learning can be considered as the course content is developed to the learning modules for all students in the course.

5. Conclusion

The purpose of this study was to demonstrate how an approach using photovoice assessment was incorporated into the supply chain problem identification and proposing relevant solutions within a mini term project in a Manuafacturing Information Management course that provided more realistic industrial problem solving environment for the Engineering Technology students. Majority of the projects proposed by the students incorporated problems related to sustainability of the supply chains and what can be done to improve some of the issues related to sustainable supply chains. Students were able to research the suuply chain problems and proposed solutions for the bottlenecks using visual tools such as VSM mapping technics. The mini project was well received by students based on the student course survey feedback and student provided photovoice assessments.

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Appendix A: Project Directions, Timelines, and Scoring

Project Guidelines:

Throughout the term, variety of specific OM topics were discussed. Some of these may apply to your personal job (co-op) i.e. application of a concept may make you more effective in your present position or help prepare you for other responsibilities.

By the end of this term project assignment, students will be able to:

1) Define the purpose and objectives of the **product** that will be aimed for the supply chain.

2) Describe how to apply process and value stream mapping for product/process design.

3) Create a detailed process/product value stream map (VSM) that describes how the supply chain is currently performed.

4) Create cartoon(s) to illustrate current and relevant supply chain challenges for the **chosen product.**

5) Identify and define appropriate **performance measures** for the supply chain.

6) Evaluate **at a minimum two (2) alternative process/ supply chain designs** within the supply chain that will reduce **waste** and **create more sustainable supply chain** for the chosen product. (Come up with two VSMs).

7) Select the best alternative supply chain using appropriate **performance measures.**

Identify and define new potential business opportunity (es) that can be generated by the improved supply chain. (Entrepreneurial mindset). You can use the Value Proposition Canvas and/or Business Model Canvas to demonstrate the potential new business opportunities. Within the links below, a short video is provided at the bottom of the page explaining each canvas:

https://www.strategyzer.com/canvas/value-proposition-canvas

https://www.strategyzer.com/canvas/business-model-canvas

8) Define and select the appropriate equipment and technology for the supply chain necessary to invest for the improved supply chain.

9) Develop an implementation plan to introduce the new or revised supplied chain including newly proposed process design (s).

10) Present challenge cartoons (team competition) and before and after VSMs (current and future state) for the supply chain with the emphasis on waste reduction and sustainability of the supply chain.

11) Create and submit Metacognitive Reflection Assessment as individual team member (see attached example). There will be two versions of this assessment, one for mid-term one for final (improved).

12) Term paper report should be easy to read and include all the elements discussed above. However, organize your report so that somebody may be able to find information quickly and easily. So, you might like to include tables, charts, lists, figures, pictures, cartoons, etc. where appropriate.

13) Students can work in groups of 3 (maximum team size)

Project Deliverables:
Be sure that the following items are included in your report:

- **Create and submit** Metacognitive Reflection Assessment **as individual student submission Due: 10/13/2022, 5 PM**
- A mid-term **technical team report I** including partial action items listed above including challenge cartoons, VSMs (current and future state), problem definition and proposed action plans, expected monetary value of potential improvements. Mid-Term **technical team report: 10/13/4022, 5 PM**
- Final **technical team report II** all the action items listed above including challenge cartoons, VSMs, problem analysis and action plans, expected monetary value of your OM improvements, waste reductions, etc. Due on: **12/01/2022, 5 PM**
- Final **team oral presentation: 12/01/2022, 5 PM**

You should justify all of your recommendations. Be sure to include as much detail as possible. Your report should not exceed 15 pages with Times New Roman font of 12, 1.5 line spacing excluding any appendices you may have

The technical report and oral presentation will be worth **100 points** toward your final grade and will be evaluated as follows:

- Individual student Metacognitive Reflection Assessment: 20%
- Online participation in term project discussion forum: 10%
- Use of calculations, tables, figures, charts (VSMs), cartoons (art), technical content, justification, grammar, readability, and completeness and conclusions of Team Technical report I & II: 50%
- Team Oral presentation: 20%

APPENDIX B- Sample Student Team Submitted PhotoVoice Metacognitive Assessment, VSM Charts, Challenge Cartoons & Proposed Solution with Monetary Value

Metacognitive Assessment

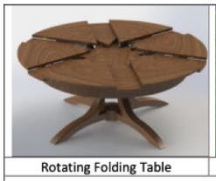
3D Printed Table

Futuristic Mini-Fridge Table

Wayfair Business Model

Applying the principles of entrepreneurship to the curriculum has forced us to consider an addition step in the design and manufacturing. Considering how the finished product will now satisfy a need or to be able to improve or implement changes to the supply line are crucial considerations as an entrepreneur. Considering the first image, it shows a new and possibly sustainable way of redesigning the product itself. A consideration like his also has benefits to the small business target audience. Since continuous production or even bath production may not always be possible, this differentiates the product and even lets the end user have a greater degree of freedom in customizing the piece. The other opportunity that we noticed was the rise of smart technology as the internet of things continues to rapidly expand. While now shifting to provide as much utility as possible within as much space as possible, compact designs such as the smart table which houses a minifridge, lights, outlets, and wireless charging capabilities. While reducing the amount of space and clutter lends this product to a market of tech savvy late teens and early adults. This allows engineering with an end user in mind which furthers the best of both principles. Finally, as inventory such as furniture requires a lot of storage and incurs much more export / misc. costs, we considered changing the way the business model operated in order to have put together furniture that ships from a warehouse. In addition, avoiding showrooms or storefronts also saves on rental costs which is as important to an entrepreneur as it is to an engineer.

Figure 6: Entrepreneurial Mindset Perspective



Rotating Folding Table

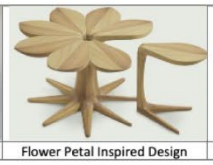
Picnic Table Design

Machine 3D Printing Furniture

Taking inspiration from the arts and applying them to STEM truly takes it a step further in terms of customer consideration as well as providing the aesthetics that customers may personally desire when it comes to purchasing a table. As an entrepreneurial spirit, it is important to consider how to make a distinctive product and as shown in the first image, this can be done in a variety of ways. Considering the rotating folding table, this promotes uses of the arts in design and usage. Considering the elegant design, it is immediately visually appealing. However, in being able to fold up, it applies a level of consumer benefit as this can accommodate small apartments / gathering to larger banquets. This is also beneficial because the rotating face of the table also draws inspiration from Chinese cuisine and dining habits. Since it is traditional to incorporates many smaller dishes that are shared, this sort of design finds itself a new possible target market which is only possible due to STEAM. Similarly, the second image depicts a large picnic table assembly which notably draws inspiration for the design from nature itself. While this is more so simply an art installation or creative piece, I believe that it still shared value in how sometimes in the process it can become more so about the art than the engineering principles that it was founded on. As with most CAD and 3-D modelling software's, artistic demands are always high. Participating in this form of engineering has proven how important it is to incorporate more of the fine arts into our technical analysis as it opens the door for new opportunities. Similarly, possibly saddled with sustainability issues, or even looking to take the advantages of 3-D printing to a larger scale, this offers a whole new set of possibilities with furniture. This is something to consider moving forward as well since a user can optimally even contribute to the design stages in order to create a customized piece.

Figure 7: Artistic Perspective

Recycled Paper Table



Flower Petal Inspired Design

Crop Seeding Honeycombs

Considering sustainability and environmental factors is essential for multiple reasons as someone who must put much consideration into materials and resources. Since this is such a big concern, manufacturers must now look elsewhere into finding the proper resources to create their products. For us, we considering looking into the benefits of recycled material such as paper and plastics to create Furniture that can look just as good but reduced its environmental footprint. this also comes at a time where inflation and increase shipping costs have left manufacturers scrambling to cover costs. In the second image there is also a depiction of a flower petal design for a table which conveniently allows the table to be broken up to form individual sections. I personally considered it to be perfect for the classroom setting as this would allow for collaborative work with the separating petals allowing for individualized tasks. This nature shaped design also reminds of how it almost appears to be honeycomb shaped. Showing the benefits of the design as seen in nature by beehives, they offer great structural strength while being space efficient. This allows designs like these to be more dynamic in application and presentation. Considering the impact that nature and the environment has on our designs and processes is one of many steps required in reducing waste and being conscious.

Figure 8: Environmental Perspective

VSM (Value Stream Mapping)

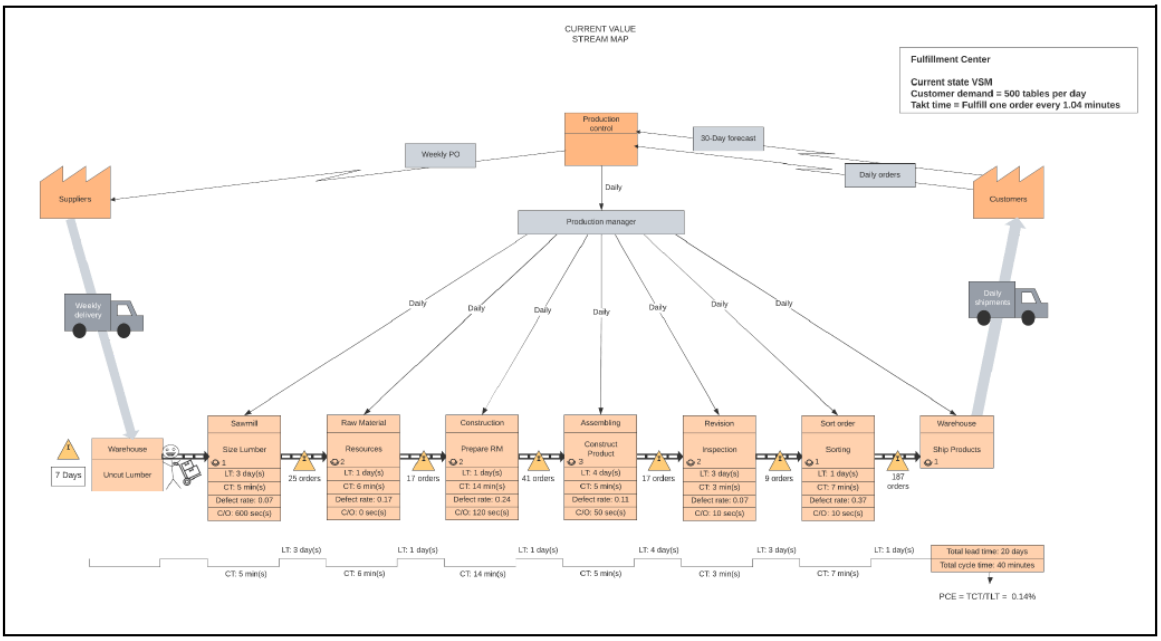


Figure 1: Current State VSM of an Estimated Furniture Manufacturer

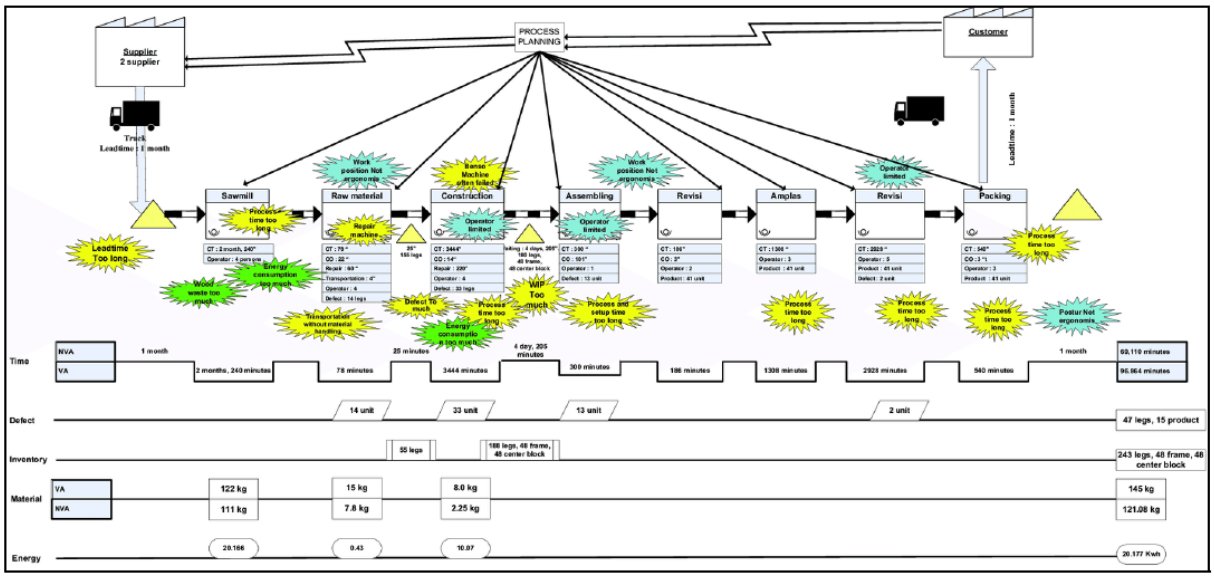


Figure 2: Comparison VSM of Industry

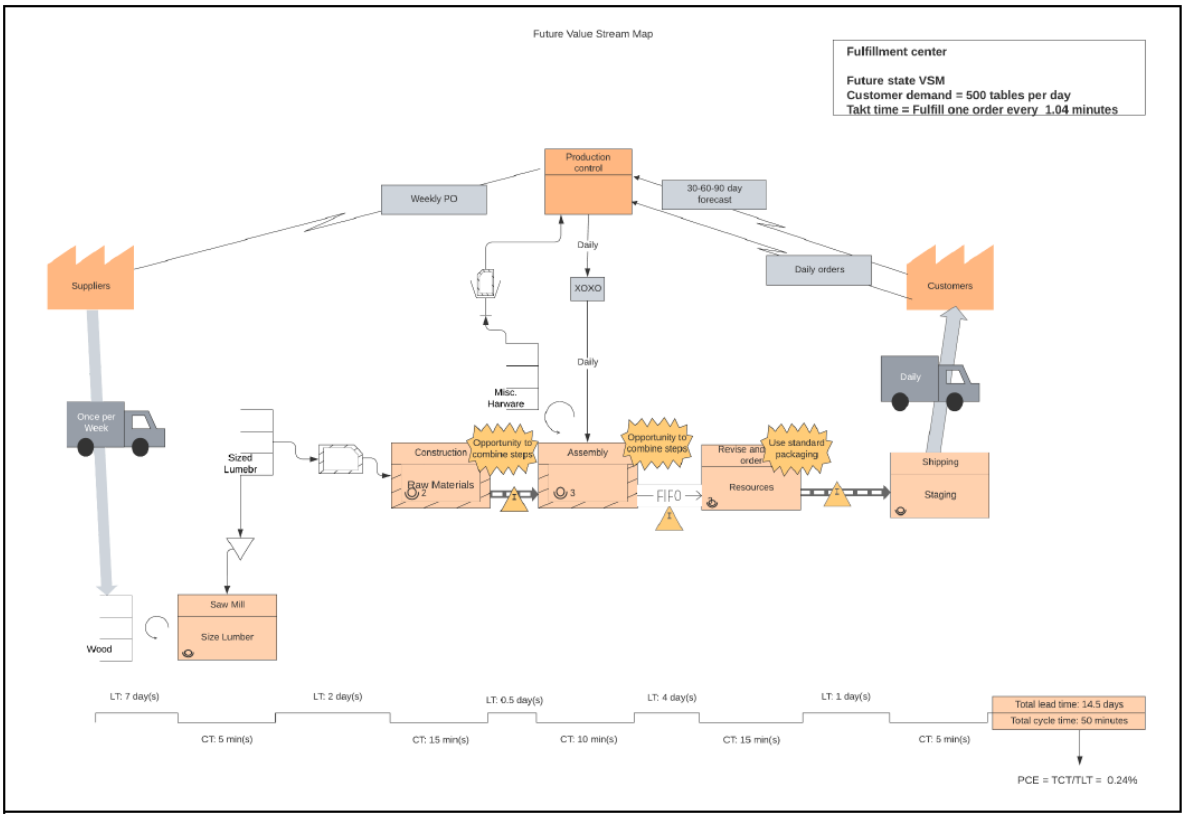


Figure 3: First iteration of Future State VSM

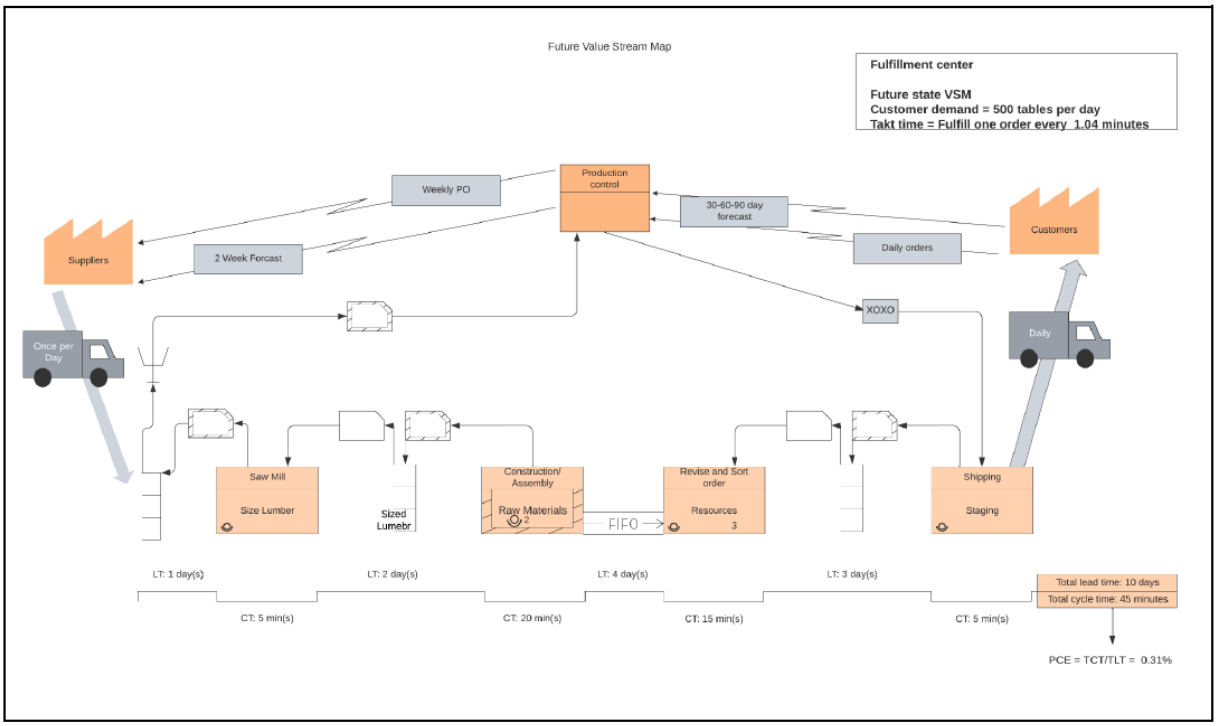


Figure 4: Final Future State VSM

Challenge Cartoons

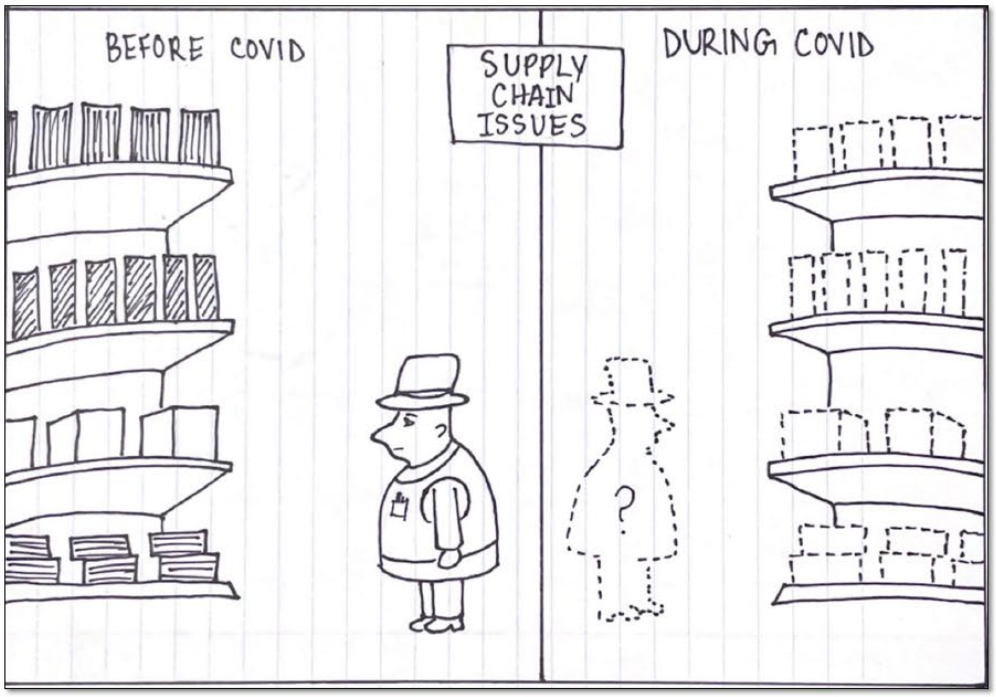


Figure 5: Shortage of Supply and Employees due to COVID-19

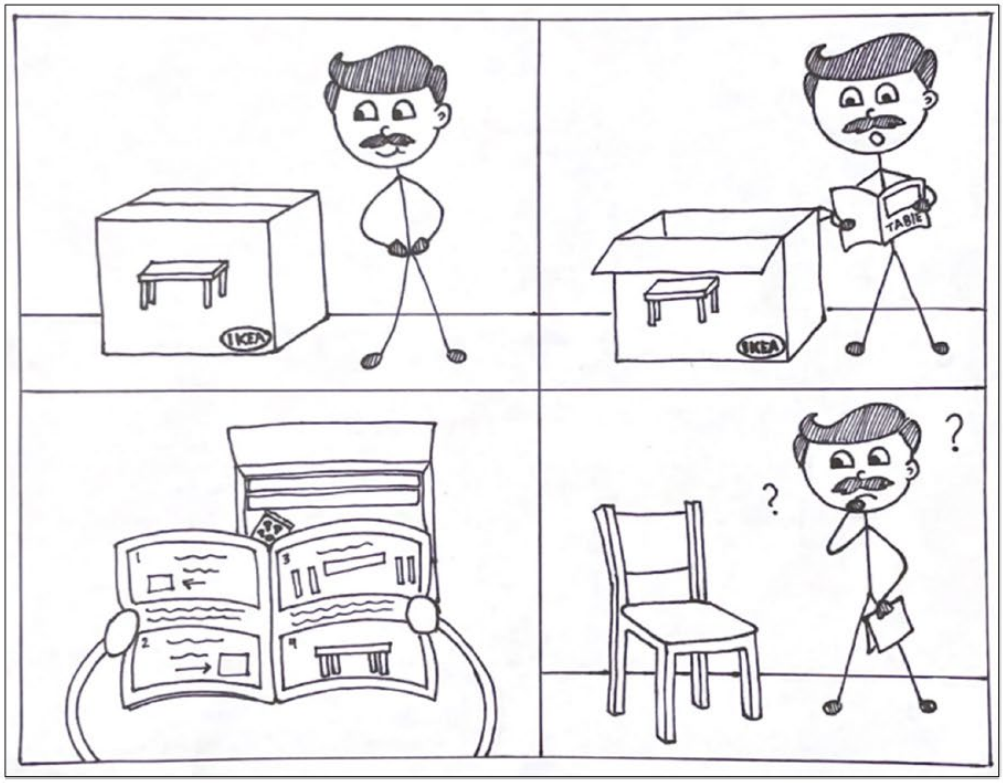


Figure 6: Unclear Assembly Instructions for Consumers

Monetary Savings

Table 1: Comparing Solutions - Cross-Docking and On-Shoring Procurement

	Cross Docking	On-Shoring Procurement
Transportation	= $5500 (avg. per shipping container) * 30 (*a* days) = $165,000	= $1500 (avg. per shipping container) * 30 (*a* days) = $45,000
Dock Holding Time Costs (Potential)	= $1225*b* (cost per shipping container)* 36 hrs (avg hrs waiting during cross docking) =$44100 (potential additional earnings per container after limiting cross docking)	= $550*b* (cost per shipping container)* 20 hrs (avg hrs waiting during cross docking) =$11000 (potential additional earnings per container after limiting cross docking)
Late Shipment Fees	= $475*c*d* (avg. late fee per shipping container per hr.)	= $475 *c*d* (avg. late fee per shipping container per hr.)
Total:	= (Transportation) + (Dock Holding Time Costs) + (Late Shipment Fees) = ($5500*30) + ($1225*50*(b)*36) + ($475*30*10) =~$2.51 million	= (Transportation) + (Dock Holding Time Costs) + (Late Shipment Fees) = ($1500*30) + ($550*20*(b)*36) + ($475*30*10) =~$0.58 million

[11] Corden, A., & Sainsbury, R. (2006). Using verbatim quotations in reporting qualitative social research: researchers' views: York: University of York.