International Conference on Industry, Engineering, and Management Systems

March 14-16, 2016

Dear Conference Participants:

It is with pleasure that we present to you the Proceedings of the 2016 International Conference on Industry, Engineering and Management Systems (IEMS). The papers presented this year consistently represented high quality scholarship in the authors' respective fields. The papers covered a wide range of topics in the business and engineering disciplines, integrating concepts that further the mission of the IEMS Conference.

We present these Proceedings to you to enable your own thought leadership so that you may share your presentations and papers in the future at our IEMS conference.

These proceedings would not have been made possible without the valuable contributions of our Track Chairs for the time and effort they spent reviewing the papers and coordinating our conference sessions. Thank-you also to our Administrative Coordinator, Elki Issa, whose work behind the scenes helps make our Conference a success.

We look forward to seeing you at IEMS 2017!

Warmest Regards,

Sandy Furterer, Ph.D., MBA
IEMS Publications Editor

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Polyethylene Layer Thickness of Auxetic Artificial Knee Implant

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Abstract

The knee joint works as a moving connection between the femur and tibia bones of a leg. Artificial knee arthroplasty is a surgical process in which all diseased joints are replaced with artificial joints. The use of auxetic structures in designing the orthopedic implants optimize the design and minimize its weight. The present work intends to investigate the thickness of the polyethylene layer which is one of the important factors for the life of the artificial knee joint. The present work also provides a novel design for human knee tibia stem using the auxetic cellular structures. It has been found that the strength of polyethylene and the strength of cement (adhesive) constituents of the artificial knee are increased with maximum polyethylene layer thickness (10mm) available in hospitals.
Index Terms—Artificial knee replacement, Novel design of tibia stem, Auxetic cellular structures, Finite element analysis of knee joint, Orthopedic implants.

I. Introduction

The knee joint works as a hinge joint which involves rotational and many other types of movement. Normally the knee joint consists of two bones Femur (upper part), Tibia (lower part), and Patella. For a normal knee function, the smoothness becomes important between the upper and lower bones of the knee joint.

All knee joint bones surfaces which are in contact with each other are covered with a smooth sliding surface called articular cartilage. In most of the cases cartilage injured by injuries, overuse, obesity, poor joint alignment, age, inflammatory conditions, and genetic causes. The smoothness of the diseased cartilage reduces which leads to progressive roughness of this biological bearing.

The reduced cartilage smoothness results as pain, swelling, and lack of movement in the knee joint. The infection of the synovial membrane of the knee joint can cause damage of cartilage and results in a total knee replacement.

Total knee replacement is a surgical operation in which the diseased, or damaged surfaces are replaced with artificial surfaces [1-2]. Materials which are used for artificial surfaces should be strong, durable and also produce less friction for the joint functioning.

The thickness of the ultra-high molecular weight polyethylene (UHMWPE) layer is one of the critical design parameter in artificial knee replacements. Yet there is no upper limit of the thickness discussed in the literature. Many statistical analysis was adopted to test the influence of polyethylene layer dimensions [3-4]. Standard specification for Knee Replacement Prosthesis includes total knee replacement (TKR) and unicondylar knee replacement (UKR) prostheses of both fixed and

mobile bearing varieties, and for primary or revision surgeries [ASTM F2083 – 12]. For TKR, the contact pressure tests should be performed at various flexion angles, with 0°, 15°, 30°, 60°, 90°, and high flexion above 125° are recommended [ASTM F2083 – 12].

Standard Test Method for Determination of Total Knee Replacement Constraint covers the establishment of a database of total knee replacement (TKR) motion characteristics with the intent of developing guidelines for the assignment of constraint criteria to TKR designs [ASTM F1223 – 14]. Auxetic cellular structures have attracted considerable interest in recent years due to their unique mechanical properties resulting from a negative Poisson's ratio versus a new field of endeavor is to study materials exhibiting negative Poisson's ratio (NPR) [5]. The aim of the present work is to design a novel tibia stem using auxetic cellular structures and analyze the choice of polyethylene layer based on reflection on all artificial knee constituents.

1. Components of Artificial Knee Joint

The artificial knee joint has two components, one is a metal which is usually made of Ni–chrome or titanium and the other is made of plastic material known as ultra-high molecular weight polyethylene (UHMWPE), as shown in Fig. 1.

Knee replacement surgery also known as knee arthroplasty can help in pain relief and restore functioning of diseased knee joints. The major reason of artificial knee joint failure is the loosening of contact between metal or cement with the bone, and the damage of the polyethylene layer. Several advances are available which can predict the life of an artificial knee joint, but the contact loosening may require a revision.

The current research presents a novel design of tibia stem and investigation of maximum Von-Mises stresses in different components of artificial knee by changing the polyethylene layer thickness.

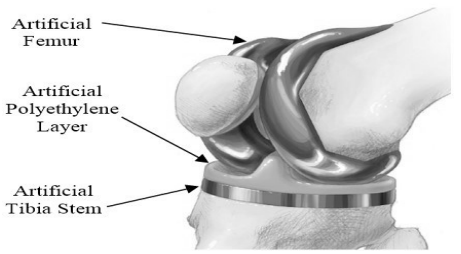


Fig. 1. Components of Artificial knee joint.

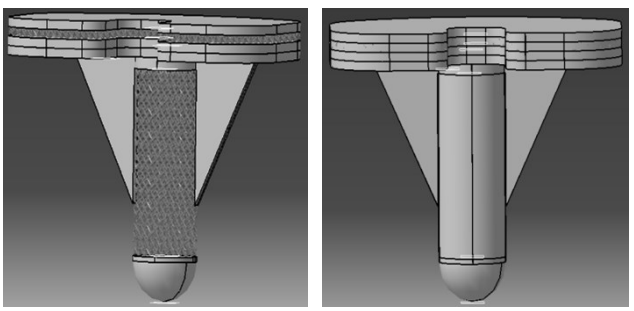
2. Auxetic Structure Applications

Due to unique mechanical properties of auxetic cellular structures they have many different applications. Applications have been projected from wine bottle corks [6] to radome sandwich panel cores [7]. Auxetic cellular structures also used in defense accessories, textile, fasteners, mass filters, and air seat cushions. Due to their acoustic properties they could also be used in piezoelectric devices [8].

Auxetic structures could also be potentially used in mega scale structures, tall buildings and bridges due to their superior stiffness. A considerable amount of work is currently focusing on auxetic materials and their applications [9]. Their deformation characteristics have made them good candidates in biomedical applications.

One of the most common causes for implant revision is loosening of the component, which is mostly caused by bone remodeling [10]. Bone is a living tissue that is constantly changing due to external forces to optimize its structure and minimize its weight [11]. Bone will increase in density when experiencing a dynamic load, and it will decrease in density when experiencing a static load or no load at all. This is a common problem for astronauts when spending an extended amount of time in microgravity. Older people experience the same problem when they become less active, and their condition is referred to as osteoporosis.

The novel design in the present work optimize the tibia stem structure and minimize its weight by using the auxetic cellular structures as compared to the solid metal implant as shown in Fig. 2.



(a) (b)

Fig. 2. (a) Tibia Stem with auxetic cellular structures; (b) Solid Tibia Stem.

3. Solid and Finite Element Model Development

The current research is on the Sigma knee design which is use by orthopedic surgeons at King Khalid

University Hospital (K.K.U.H). There are many kinds of cellular structures available which are different in their shapes like honeycomb, diamond, triangular, rectangular, hexagonal etc. Reticulated mesh structures are developed from Materialise/Magics [12] software. After inserting the cellular structures into the tibia stem the Sigma knee joint modeled as a 3D solid model, as shown in Fig. 3. 3D mesh model created as shown in Fig. 4 from Hyperworks® (86,868 nodes and 2, 53,773 elements). Finite element analysis (FEA) is one of the effective technique for the strength prediction of the cellular structures [13]. The designed 3-Dimensional models were imported into a finite element analysis software package ANSYS®.

The implemented cement (adhesive) thickness was adapted from actual surgery practices of King Khalid University Hospital, Saudi Arabia.

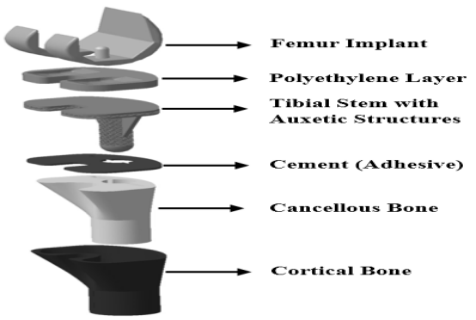


Fig. 3. Blow-Up View of the Solid Artificial Knee Model.

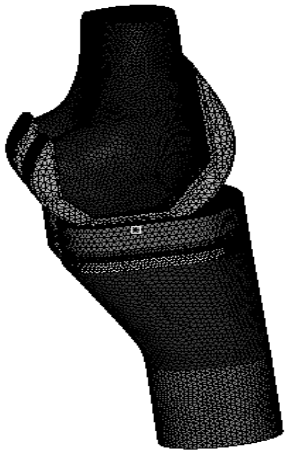


Fig. 4. 3D Mesh Model by Hyperworks®.

The knee joint finite element model boundary and loading conditions are shown in Fig. 5. The artificial knee material properties are listed in Table 1[1].

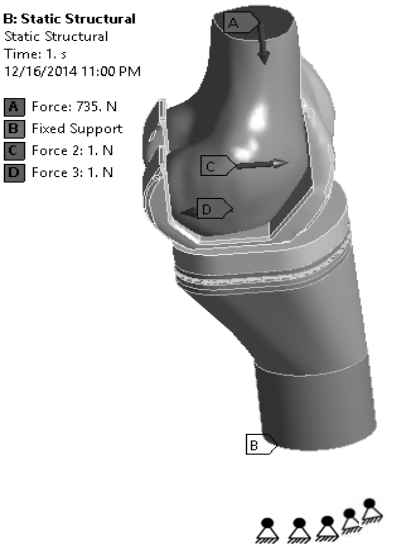


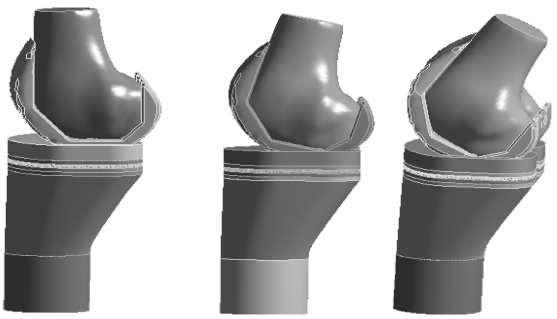
Fig. 5. Assigned loading and constrain conditions of artificial knee solid model.

Fig. 5 shows that the lower part of the knee model is fixed in all directions. For loading conditions we have categorized loads into age group (childhood, teenagers and adults) according to the weight of the body. We have selected the loads from 245N to 735N according to the body weight which is distributed over 492 nodes, plus 1N.m torsion load is also applied [1].

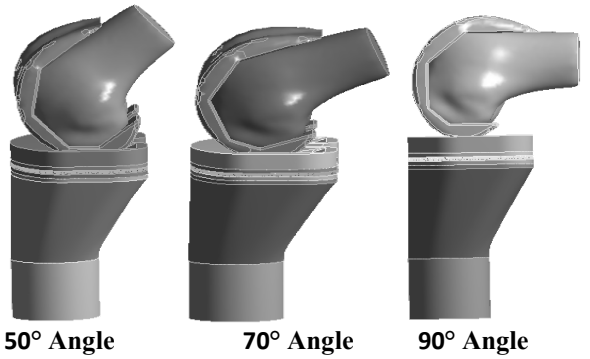
Material	Young's Modulus (MPa)	Poisson's Ratio	Yield Strength (MPa)
Cancellous Bone	5.2E2	0.29	11
Cortical Bone	3.0E4	0.29	50
Cement (Adhesive)	2.5E3	0.38	50
Ni-Chrome Alloy	2.0E5	0.3	755
Polyethylene	2.3E3	0.32	55
Ti-6Al-4V	1.1E5	0.24	880

Table 1. Material properties of artificial knee FE model.

For TKR, the load is applied at various flexion angles, with 0°, 15°, 30°, 50°, 70°, 90°, and high flexion above 130° are selected [ASTM F2083 – 12] as shown in Fig. 6.



0° Angle **15° Angle** **30° Angle**



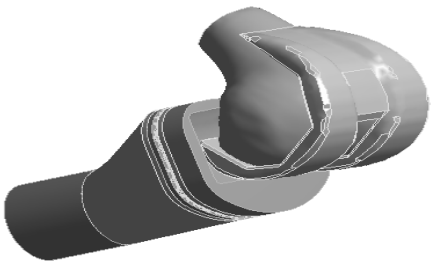


Fig. 6. Flexion angles of artificial knee solid model [ASTM F2083 – 12].

The following boundary conditions were assumed throughout the finite element analysis:

- The problem is three dimensional.
- All materials properties are isotropic.
- Two friction contact surfaces are modeled between artificial femur and polyethylene bearing areas.
- No contact stresses assigned on adhesive layer.
- Elastic-plastic FE analysis is considered in the current analysis.

Since the polyethylene layer is the most critical component of the artificial knee joint, the present work intends on investigating the effect of thickness variation on knee joint strength. The main objective is to maximize the life of polyethylene layer, so it could stay with the patient for longer span before revision, without scarifying its strength. To achieve this objective, three finite element models were built. The first model had a polyethylene layer 8 mm thick, which is the most frequent design used currently at King Khalid University Hospital. The other two models were built to represent the thicker polyethylene layers of 9 and 10 mm (available also at King Khalid University Hospital).

The 4-noded linear tetrahedron element was used to generate the FE mesh, using 86,868 nodes and 2, 53,773 elements for all three FE models, as shown in Fig. 4.

4. Artificial Knee Joint Strength Prediction

The 3D finite element meshes model created as shown in Fig. 4 from Hyperworks®. Altair Hyperworks is a high-performance finite element pre-processor to prepare the meshing models.

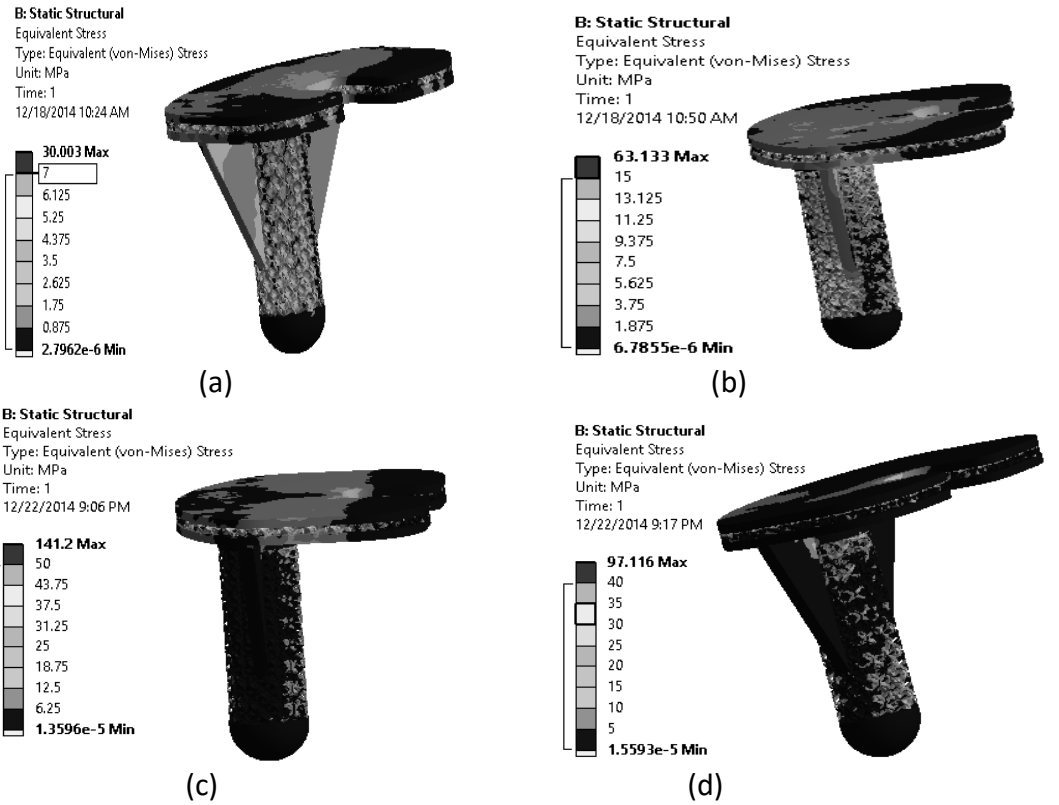


Fig. 7. Stress contours at various flexion angles of Tibia stem component (a) 0°, (b) 30°, (c) 90°, (d) 130°.

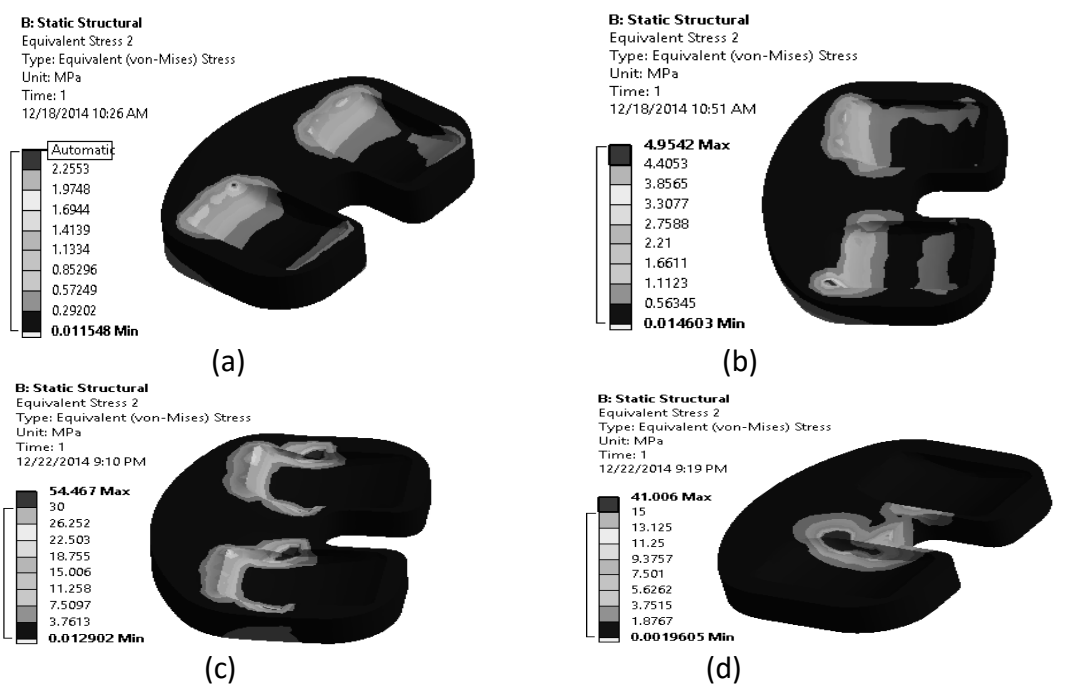


Fig. 8. Stress contours at various flexion angles of Polyethylene layer component (a) 0°, (b) 30°, (c) 90°, (d) 130°.

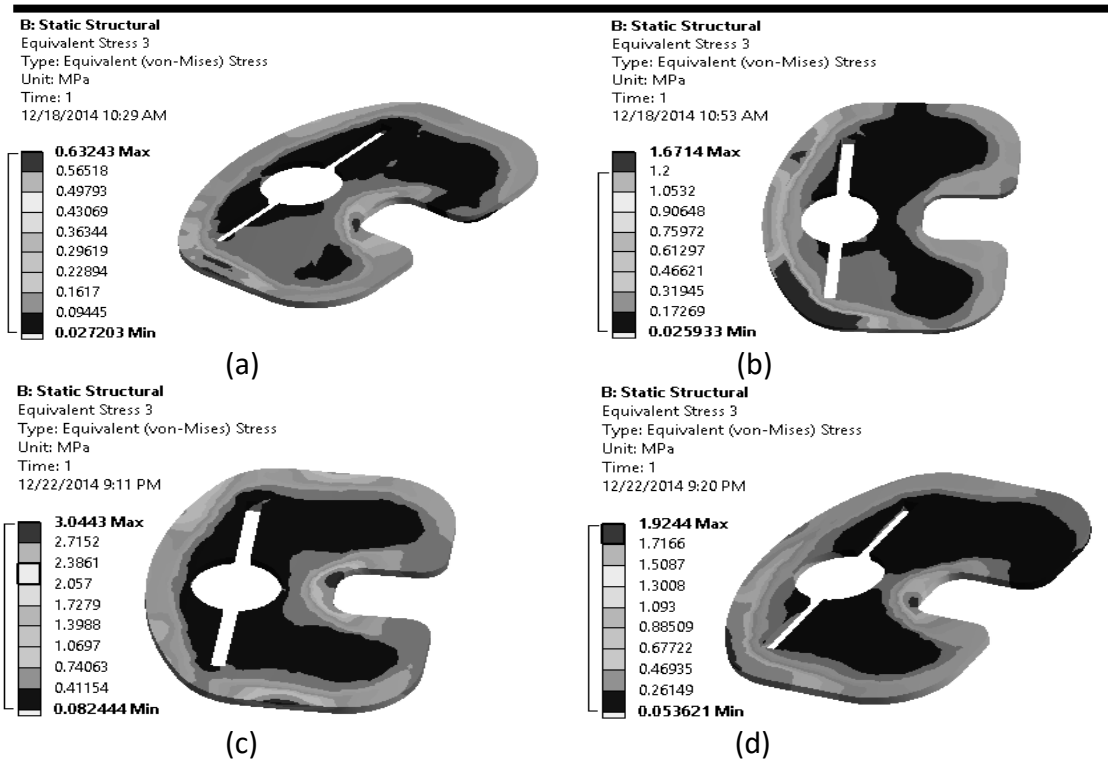


Fig. 9. Stress contours at various flexion angles of Cement (adhesive) component (a) 0°, (b) 30°, (c) 90°, (d) 130°.

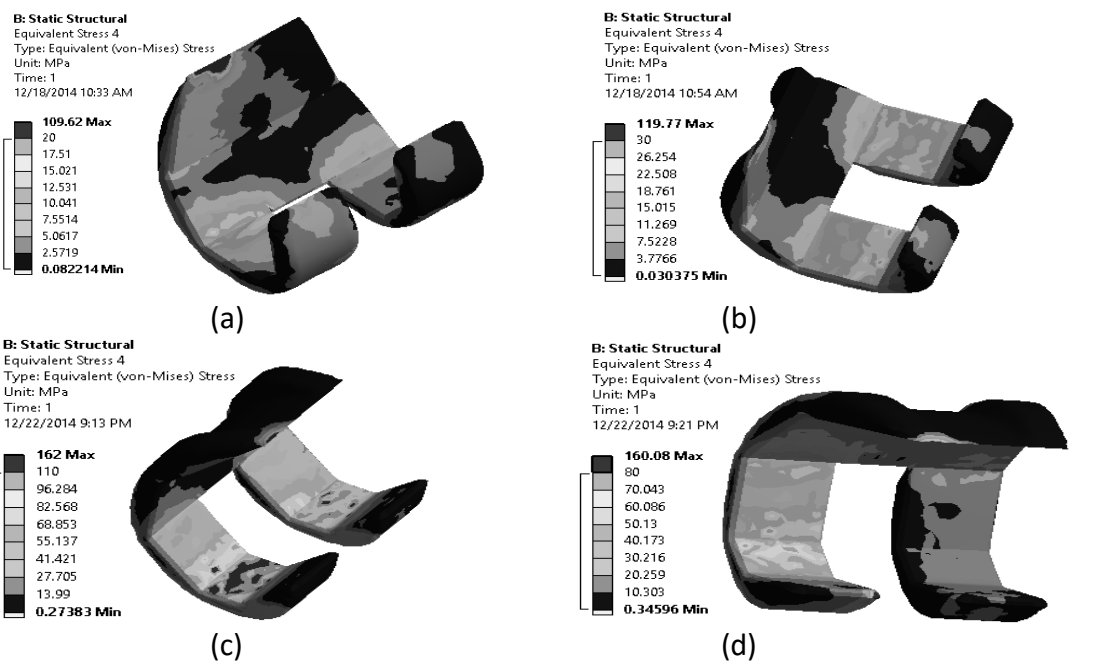
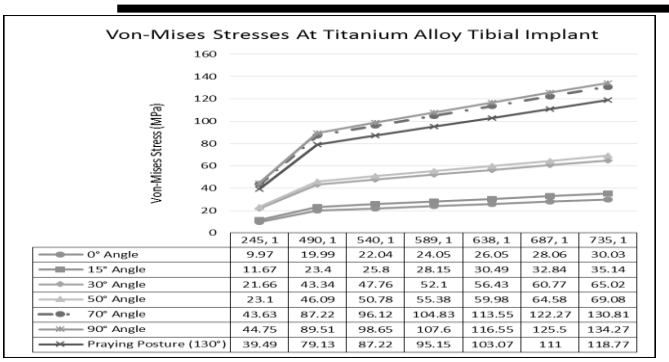


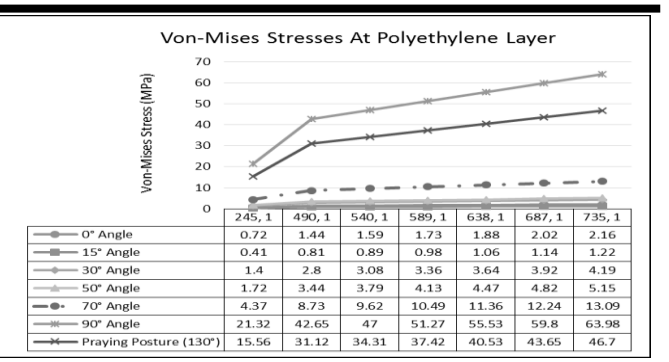
Fig. 10. Stress contours at various flexion angles of Femur component (a) 0°, (b) 30°, (c) 90°, (d) 130°.

Figures 7-10 show that all predicted von-misses stresses are below the ultimate limit of the corresponding materials.



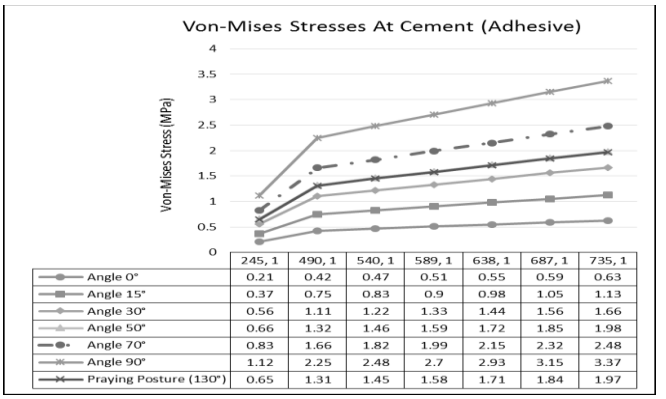
	245, 1	490, 1	540, 1	589, 1	638, 1	687, 1	735, 1
0° Angle	9.97	19.99	22.04	24.05	26.05	28.06	30.03
15° Angle	11.67	23.4	25.8	28.15	30.49	32.84	35.14
30° Angle	21.66	43.34	47.76	52.1	56.43	60.77	65.02
50° Angle	23.1	46.09	50.78	55.38	59.98	64.58	69.08
70° Angle	43.63	87.22	96.12	104.83	113.55	122.27	130.81
90° Angle	44.75	89.51	98.65	107.6	116.55	125.5	134.27
Praying Posture (130°)	39.49	79.13	87.22	95.15	103.07	111	118.77

(a)



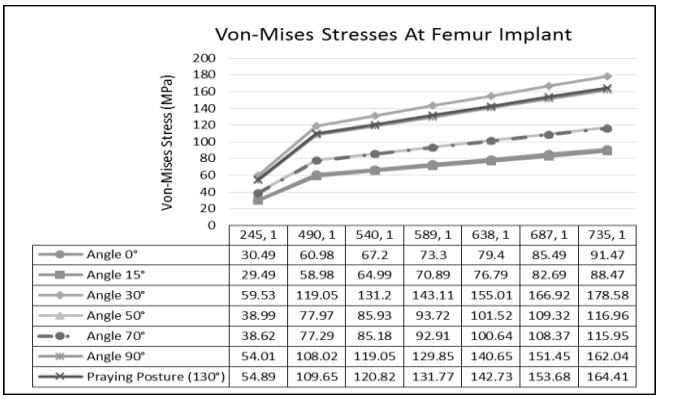
	245, 1	490, 1	540, 1	589, 1	638, 1	687, 1	735, 1
0° Angle	0.72	1.44	1.59	1.73	1.88	2.02	2.16
15° Angle	0.41	0.81	0.89	0.98	1.06	1.14	1.22
30° Angle	1.4	2.8	3.08	3.36	3.64	3.92	4.19
50° Angle	1.72	3.44	3.79	4.13	4.47	4.82	5.15
70° Angle	4.37	8.73	9.62	10.49	11.36	12.24	13.09
90° Angle	21.32	42.65	47	51.27	55.53	59.8	63.98
Praying Posture (130°)	15.56	31.12	34.31	37.42	40.53	43.65	46.7

(b)



	245, 1	490, 1	540, 1	589, 1	638, 1	687, 1	735, 1
Angle 0°	0.21	0.42	0.47	0.51	0.55	0.59	0.63
Angle 15°	0.37	0.75	0.83	0.9	0.98	1.05	1.13
Angle 30°	0.56	1.11	1.22	1.33	1.44	1.56	1.66
Angle 50°	0.66	1.32	1.46	1.59	1.72	1.85	1.98
Angle 70°	0.83	1.66	1.82	1.99	2.15	2.32	2.48
Angle 90°	1.12	2.25	2.48	2.7	2.93	3.15	3.37
Praying Posture (130°)	0.65	1.31	1.45	1.58	1.71	1.84	1.97

(c)

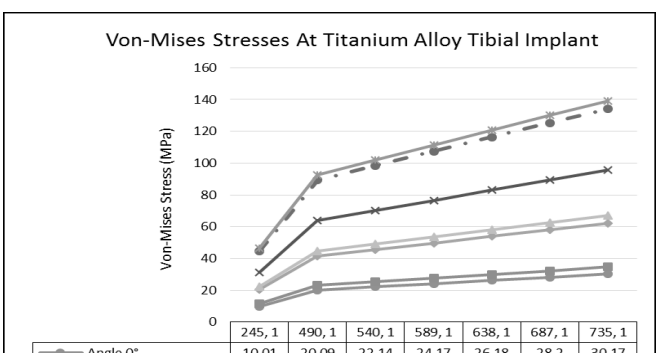


	245, 1	490, 1	540, 1	589, 1	638, 1	687, 1	735, 1
Angle 0°	30.49	60.98	67.2	73.3	79.4	85.49	91.47
Angle 15°	29.49	58.98	64.99	70.89	76.79	82.69	88.47
Angle 30°	59.53	119.05	131.2	143.11	155.01	166.92	178.58
Angle 50°	38.99	77.97	85.93	93.72	101.52	109.32	116.96
Angle 70°	38.62	77.29	85.18	92.91	100.64	108.37	115.95
Angle 90°	54.01	108.02	119.05	129.85	140.65	151.45	162.04
Praying Posture (130°)	54.89	109.65	120.82	131.77	142.73	153.68	164.41

(d)

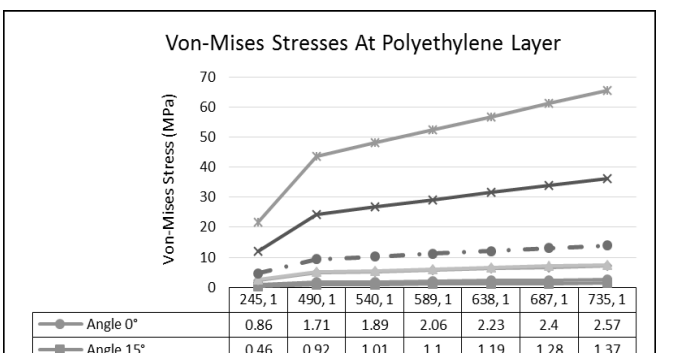
Fig. 11. Predicted maximum von-misses stress (MPa) for 8mm Polyethylene layer thickness model.

Fig. 11 shows that predicted von-misses stresses increases with the increase of flexion angle up to 90°, above which the von-misses stresses start to decrease for components Tibia stem, Polyethylene layer and Cement. But for Femur component maximum von-misses are at angle 30° (climbing posture).



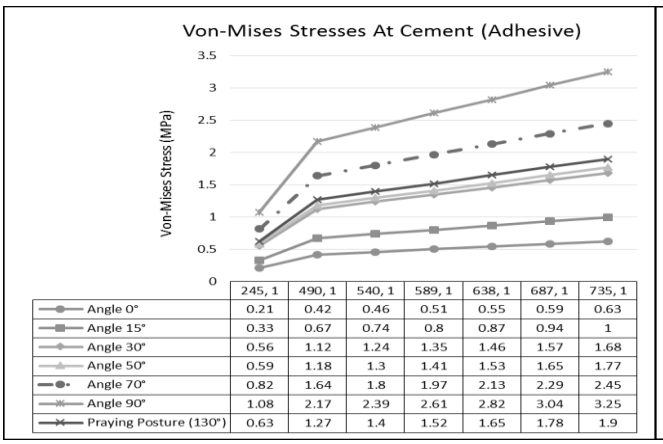
	245, 1	490, 1	540, 1	589, 1	638, 1	687, 1	735, 1
Angle 0°	10.01	20.09	22.14	24.17	26.18	28.2	30.17
Angle 15°	11.5	23.07	25.43	27.75	30.06	32.38	34.65
Angle 30°	20.69	41.4	45.62	49.76	53.91	58.05	62.1
Angle 50°	22.41	44.73	49.28	53.76	58.23	62.7	67.08
Angle 70°	44.72	89.4	98.52	107.45	116.39	125.33	134.08
Angle 90°	46.33	92.67	102.13	111.39	120.66	129.93	139.01
Praying Posture (130°)	31.37	63.73	70.23	76.61	82.98	89.35	95.59

(a)



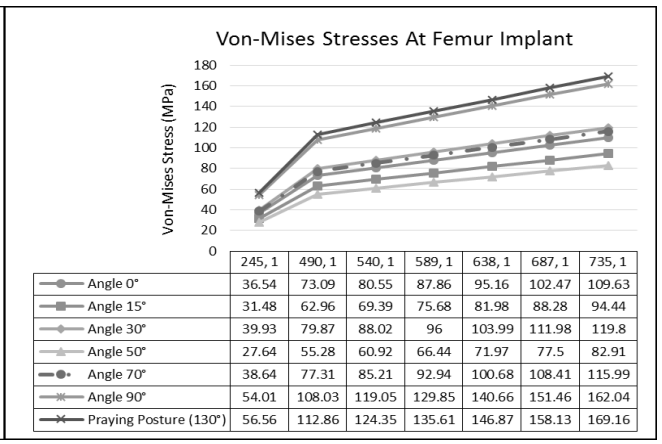
	245, 1	490, 1	540, 1	589, 1	638, 1	687, 1	735, 1
Angle 0°	0.86	1.71	1.89	2.06	2.23	2.4	2.57
Angle 15°	0.46	0.92	1.01	1.1	1.19	1.28	1.37
Angle 30°	2.39	4.79	5.27	5.74	6.22	6.7	7.17
Angle 50°	2.52	5.04	5.56	6.06	6.56	7.07	7.56
Angle 70°	4.66	9.31	10.26	11.19	12.12	13.05	13.97
Angle 90°	21.81	43.62	48.07	52.43	56.8	61.16	65.43
Praying Posture (130°)	12.1	24.22	26.69	29.11	31.54	33.96	36.33

(b)



	245, 1	490, 1	540, 1	589, 1	638, 1	687, 1	735, 1
Angle 0°	0.21	0.42	0.46	0.51	0.55	0.59	0.63
Angle 15°	0.33	0.67	0.74	0.8	0.87	0.94	1
Angle 30°	0.56	1.12	1.24	1.35	1.46	1.57	1.68
Angle 50°	0.59	1.18	1.3	1.41	1.53	1.65	1.77
Angle 70°	0.82	1.64	1.8	1.97	2.13	2.29	2.45
Angle 90°	1.08	2.17	2.39	2.61	2.82	3.04	3.25
Praying Posture (130°)	0.63	1.27	1.4	1.52	1.65	1.78	1.9

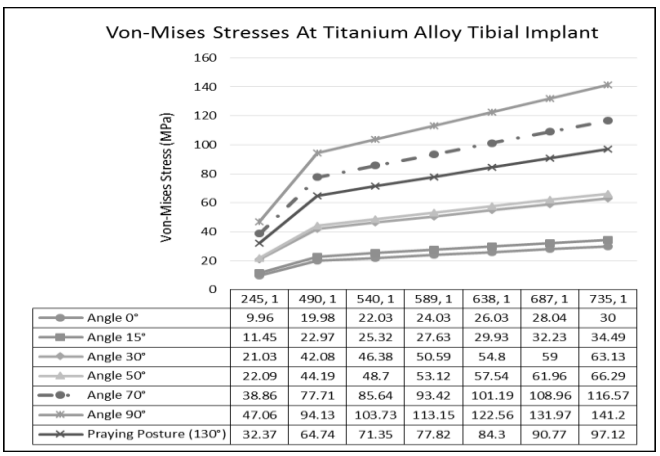
(c)



	245, 1	490, 1	540, 1	589, 1	638, 1	687, 1	735, 1
Angle 0°	36.54	73.09	80.55	87.86	95.16	102.47	109.63
Angle 15°	31.48	62.96	69.39	75.68	81.98	88.28	94.44
Angle 30°	39.93	79.87	88.02	96	103.99	111.98	119.8
Angle 50°	27.64	55.28	60.92	66.44	71.97	77.5	82.91
Angle 70°	38.64	77.31	85.21	92.94	100.68	108.41	115.99
Angle 90°	54.01	108.03	119.05	129.85	140.66	151.46	162.04
Praying Posture (130°)	56.56	112.86	124.35	135.61	146.87	158.13	169.16

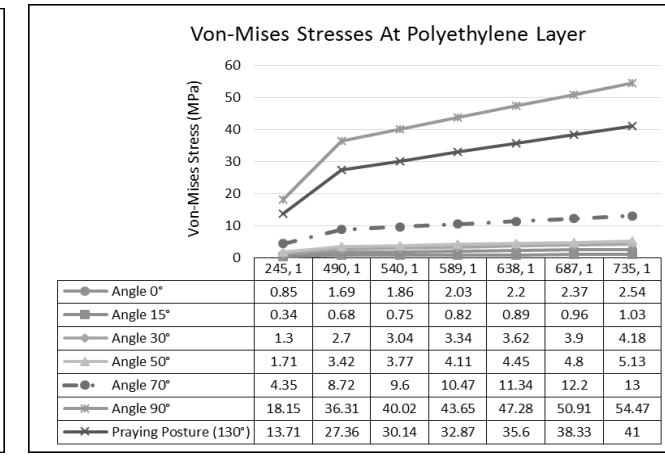
(d)

Fig. 12. Predicted maximum von-misses stress (MPa) for 9mm Polyethylene layer thickness model.



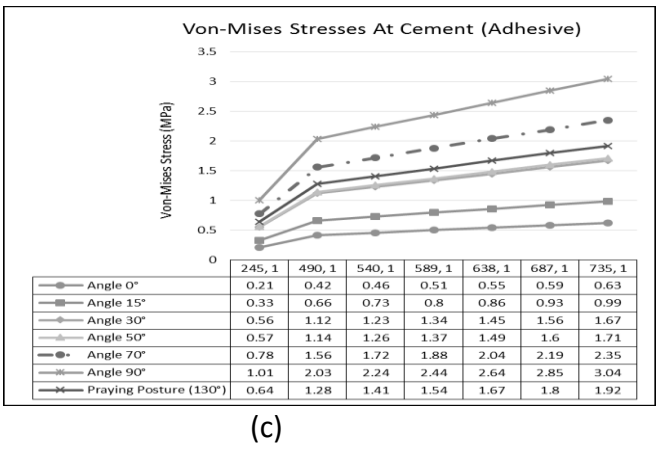
	245, 1	490, 1	540, 1	589, 1	638, 1	687, 1	735, 1
Angle 0°	9.96	19.98	22.03	24.03	26.03	28.04	30
Angle 15°	11.45	22.97	25.32	27.63	29.93	32.23	34.49
Angle 30°	21.03	42.08	46.38	50.59	54.8	59	63.13
Angle 50°	22.09	44.19	48.7	53.12	57.54	61.96	66.29
Angle 70°	38.86	77.71	85.64	93.42	101.19	108.96	116.57
Angle 90°	47.06	94.13	103.73	113.15	122.56	131.97	141.2
Praying Posture (130°)	32.37	64.74	71.35	77.82	84.3	90.77	97.12

(a)



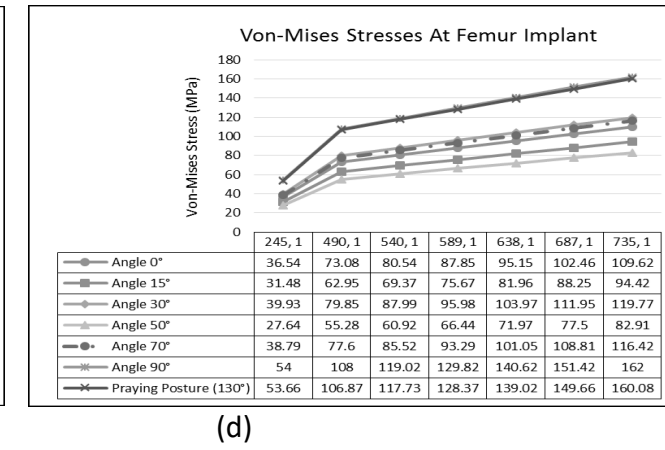
	245, 1	490, 1	540, 1	589, 1	638, 1	687, 1	735, 1
Angle 0°	0.85	1.69	1.86	2.03	2.2	2.37	2.54
Angle 15°	0.34	0.68	0.75	0.82	0.89	0.96	1.03
Angle 30°	1.3	2.7	3.04	3.34	3.62	3.9	4.18
Angle 50°	1.71	3.42	3.77	4.11	4.45	4.8	5.13
Angle 70°	4.35	8.72	9.6	10.47	11.34	12.2	13
Angle 90°	18.15	36.31	40.02	43.65	47.28	50.91	54.47
Praying Posture (130°)	13.71	27.36	30.14	32.87	35.6	38.33	41

(b)



	245, 1	490, 1	540, 1	589, 1	638, 1	687, 1	735, 1
Angle 0°	0.21	0.42	0.46	0.51	0.55	0.59	0.63
Angle 15°	0.33	0.66	0.73	0.8	0.86	0.93	0.99
Angle 30°	0.56	1.12	1.23	1.34	1.45	1.56	1.67
Angle 50°	0.57	1.14	1.26	1.37	1.49	1.6	1.71
Angle 70°	0.78	1.56	1.72	1.88	2.04	2.19	2.35
Angle 90°	1.01	2.03	2.24	2.44	2.64	2.85	3.04
Praying Posture (130°)	0.64	1.28	1.41	1.54	1.67	1.8	1.92

(c)



	245, 1	490, 1	540, 1	589, 1	638, 1	687, 1	735, 1
Angle 0°	36.54	73.08	80.54	87.85	95.15	102.46	109.62
Angle 15°	31.48	62.95	69.37	75.67	81.96	88.25	94.42
Angle 30°	39.93	79.85	87.99	95.98	103.97	111.95	119.77
Angle 50°	27.64	55.28	60.92	66.44	71.97	77.5	82.91
Angle 70°	38.79	77.6	85.52	93.29	101.05	108.81	116.42
Angle 90°	54	108	119.02	129.82	140.62	151.42	162
Praying Posture (130°)	53.66	106.87	117.73	128.37	139.02	149.66	160.08

(d)

Fig. 13. Predicted maximum von-misses stress (MPa) for 10mm Polyethylene layer thickness model.

Fig. 13 shows that predicted von-misses stresses increase with the increase of flexion angle up to 90°, above which the von-misses stresses start to decrease for components Tibia stem, Polyethylene layer, Cement and Femur.

In the beginning of analysis, a Nastran data file of the FE model was generated using Hyperworks® and then this data file is used as an input in finite element modeler of ANSYS®. In the next step a static structure module of ANSYS® is used for the predicted von-misses stresses in different components of artificial knee joint if it applies to all cases.

5. Material Analysis

Figures 7-10 show the stress contours in the four components (Tibia stem, Polyethylene layer, Cement and Femur) of the artificial knee for different loading condition from 245N to 735N. These figures make the measurements of the lengths of contact imprints possible [3]; this in turn helps estimating the contact pressure and contact areas at the articulating surfaces. If the contact area and pressure are symmetrical about the line of joint symmetry, then the wear pattern will be informally distributed and the operation is likely to last longer. However, in cases where the pattern is out of symmetry, the wear pattern is likely to be biased towards a specified bearing area of contact and the life span of the joint is likely to be shorter.

The maximum von-misses stresses developed in four components (Tibia stem, Polyethylene layer, Cement and Femur) of the artificial knee for different loading condition from 245N to 735N were calculated and plotted as shown in Fig. 11-13.

From figures 11-13, it could be concluded that the 10mm polyethylene layer thickness model came first in strengthening the most critical components (Polyethylene layer and Cement) of artificial knee joint. The maximum von-misses stresses decreases 15% in Polyethylene layer and 8% in Cement (adhesive) if we use 10mm polyethylene layer thickness when compared with 8mm.

6. CONCLUSIONS

The increased polyethylene layer thickness, results in strengthening the polyethylene layer and other components of the artificial knee joint. Among the models of artificial knee available in hospitals, the 10 mm polyethylene layer model is highly recommended for all age group patients.

7. Acknowledgment

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An Expert System of Marissa Mayer's Knowledge (CEO of Yahoo)

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Abstract

This paper describes the conceptual development of an expert system to advise those considering the top level position in a firm in the very competitive computer industry based on the expertise of Marissa Mayer who has been the CEO of Yahoo for the past three years. She had joined Yahoo as their first female software engineer in 1999. She has become a role model for female computer science and MIS students that it is possible to reach the top level position in an industry formerly dominated by males. She qualifies for the model developed by the authors to recognize heroes of the computer industry as potential experts for a computerized expert system.

1. Introduction

Since the early 1980s expert systems have been developed for the purpose of passing expertise from those with the knowledge to those who need the knowledge in a convenient and easily accessed manner. The idea is to tap the mind of the expert such that a less expertise person can solve problems normally handled by the expert without the expert having to be present. In the early 1980s, expert systems were crude, self-developed by only a few firms that saw value in them. By the late 1980s, special languages such as VP-Expert and CLIPS emerged and software shells developed to increase the ease of development of these systems. The first decades of the 21st century has witnessed the emergence of intelligent expert systems which provide access to multiple experts within a narrow field of interest.

In the 1990s with the focus on downsizing and need to cut costs in all area, many managers of large corporations had turned to expert systems to provide advice when the cost of hiring an expert (consultant) or access to a previous expert employee who has been downsized was gone. The recent interest in the first decade of the 21st century on knowledge management has caused a renewed interest in expert systems as a way to manage knowledge for easier and wider distribution. The software industry has matured to build "intelligence" into software, sometimes known as "learning systems" which can adapt themselves based on how they are used. Expert Systems continue to become more complex but require constant upkeep.

This paper captures the knowledge of a single expert in a limited domain in the computer industry. It is developed for student use to recognize heroes in the computer industry who have made significant contributions. It is a jointly written paper by two MIS professors as a continuing series of expert systems for a senior elective course in expert systems taught at

Southern Connecticut State University. This model has been useful in the classroom for the "Expert System" course for students to select their own expert and design such a system for that expert to better understand the nature of these complex systems. One student, Dana Mares, continued with an independent study course where she coded her work in CLIPS to demonstrate that the model be used to build an actual system if an appropriate language is used.

ADDITIONAL BACKGROUND TO PAPER

Since early 1990s, an elective course in the MIS program at SCSU titled "Expert Systems" has been taught periodically. In MIS work, expert systems have long been considered the most difficult and complex of all information system types. They are

included in the family of applications known as "artificial intelligence". They represent an application attempting to mimic the human brain. These applications capture the experience of an "expert" in a narrow area of expertise in computer form such that this vast "knowledge base" can be used to produce advice for a non-expert to solve a problem to which they have not gained appropriate experience as if they were equal to the expert. This 2 is quite a challenge. Students were having difficulty understanding the nature of these systems and how they differ from traditional information systems from a design standpoint. Figure 1 outlines the components of an expert system.

- Dialog Screen – Determine Nature of Problem
- Knowledge Base – A collection of "If ...Then" statements From Experts
- Inference Engine – Software to search knowledge base
- Presentation – Determine how to display advice to system user

Figure 1: Components of an Expert System

For several years in the 1990s, expert systems had fallen out of favor in business because they had been incorrectly applied to the elimination of experts, who were usually the highest paid workers in an organization outside of the managers. However, with the downsizing of the early part of the 21st century, expert systems have reappeared as a training tool for such businesses. In support of this course, which was the most challenging MIS course to teach, Dr. Mullen developed a model of an expert system to demonstrate to the students how such a system is developed using a language, CLIPS. The model involved picking two individuals a year who were experts in their field and who were living at the time so theoretically they could have been interviewed personally to capture their expertise. However, these chosen individuals were well known enough in their field to have had books and later Internet articles published about them. This was the source of information for these systems. Dr. Mullen began presenting his work at various conferences for peer comments to improve the process. A list of organizations where these papers have been

presented and published is shown as figure 2 below. Since 2003, the focus of presentations has been the IEMS Conference held each March in beautiful Cocoa Beach, Florida when the weather in Connecticut has reached its peak of winter cold and snow.

Association of Management
Decision Science Institute
Industry, Engineering, and Management Systems
Info Resource Mgmt Association

Figure 2: Conferences where expert system papers were presented

Dr. Mullen also began to utilize the model to recognize the many contributors to the advancement of computer application usage who may be seen as heroes or role models to my MIS students. Such individuals who have had prior models developed of the expertise in the computer field include Bill Gates (Microsoft); Paul Allen (Microsoft); Steven Jobs (Apple Computers); Michael Dell (Dell Computers); Lawrence Ellison

(Oracle); Scott McNealy (Sun Microsystems) and in 2011 Mark Zuckerberg, founder of Facebook, Steve Wozniak (co-founder of Apple computers). A co-author, Ms. Kramer, was added this year as a co-

author to assure the model did not die off with the retirement of Dr. Mullen for future presentations at IEMS conferences.

BACKGROUND OF MARISSA MAYER FEATURED IN THIS PAPER

Marissa Mayer was born in Wausau, Wisconsin on May 30, 1975. She graduated from the local high school in 1993. She graduated with honors from Stanford University with a Bachelor of Science in Symbolic Systems in 1997. Later, in 1999, she would earn a Master of Science degree in Computer Science from the same University. The focus of this paper is to recognize Marissa Mayer's contribution to the computer industry. Marissa Mayer began her work career interning at SRI International in Menlo Park, California and UBS's research lab in Zurich, Switzerland. In 2008, she was awarded an honorary Doctorate of Engineering from Illinois Institute of Technology. Her career at Google began in 1999 when she was hired as the first female engineer to head user interface and Web server teams. She was involved in over 100 well-known features and products. Best known of these include Google Maps, Google Earth, Street View, Google News and Gmail. For this paper,

Figure 3 below summarizes the management philosophy of Marissa Mayer.

1. Considered by some to be a micromanager due to intense focus on detail.
2. She is focused on her company's vision and known to ignore opinions of others.
3. However, she acknowledges that her success stems from hiring incredibly smart people and leading them with a hard work ethic.
4. She works hard and celebrates never getting to the bottom of her "to-do" list.
5. She strives to build future value for stockholders in a growing company.
6. She does not support "telecommuting" but believes Yahoo employees gain value from face-to-face contact.

Figure 3: Management Philosophy of Marissa Mayer

SPECIFIC DEVELOPMENT OF THIS PAPER

During the Fall 2010 semester at Southern Connecticut State University, Dr. Mullen offered the course in Expert Systems that had not been taught for five years due to lack of support from the students. It had now been advertised as an elective for both MIS and management students. Students were asked to work on a term project that required selecting an expert in a field of interest to them. Most chose sports figures or well-known managers. One student selected Mark Zuckerberg with an interest toward developing the social network system into a target marketing tool. Dr. Mullen had planned to do a paper on Mark Zuckerberg for the 2011 IEMS conference that year so got permission to combine their work into a single paper for the IEMS March 2011 conference. This also stimulated Dr. Mullen to return to his original model of using these papers to recognize the many contributors to the highly successful computer industry such that future students of the course may continue that effort rather than focus on well-known sport's millionaires. At 2012 IEMS conference, the subject was Paul Allen as co-founder of Microsoft. At 2013 IEMS conference, featured Steve Wozniak, co-founder of Apple. Dr. Mullen did retire in 2013 but continues to teach as an adjunct, mostly on-line courses. The business school of Southern Connecticut State University is progressing toward AACSB accreditation which requires adjuncts to continue to do research and present results at conferences with peer review. This generated a new focus of female executives as previously unrecognized contributors to the computer industry in particular or managerial ranks in other industries. Ms. Ellen Kramer co-authored this paper and provided the basic research regarding Marissa Mayer for use in the expert system model's focus for 2016 IEMS conference.

In developing an expert system, a knowledge engineer asks questions of an expert in order to build a knowledge base. Figure 4 contains some example questions that would be appropriate to ask of Marissa Mayer to simulate the collecting of her knowledge in the form of advice for anyone interested in managing in the fast paced computer industry. Of course, we did not have an opportunity to actually meet with Marissa Mayer herself. With appropriate funding, cooperation, and time, it would have been possible to do so for the conceptual model development. But, we could

uncover such situations from publicly published material via the Internet.

The language of an expert system is usually rule-based so that advice is shown as the answer to an "IF" question that the expert system user might have as a problem. Most of the advice from Marissa Mayer deals with her managerial philosophy. Yahoo now faces additional challenges in reorganizing itself into a profitable organization by spinning off some holdings as separate companies.

- IF your goal is to work from home, THEN your work ethics do not fit with a company wishing to grow the business.
- IF you are not willing to work hard, THEN the computer industry is NOT the right choice for you.
- IF you are not willing to focus on detail, THEN the computer industry is NOT the right choice for you.
- IF you are not an extremely smart person, THEN the computer industry is NOT the right choice for you.

Figure 4: Marissa Mayer's advice on managing in the computer industry.

This paper describes the conceptual development of an expert system to capture the knowledge of Marissa Mayer. Figure 5 depicts the conclusions reached from the writing of this paper. In the reference section at the end of this paper are 4

other similar papers written and presented at earlier conference in the series of expert systems on computer professionals known to be experts in their field. Although Dr. Mullen retired in 2013 and does not expect to teach the Expert System course at Southern Connecticut University, he saw new value to continue this series of papers for IEMS. Dr. Mullen will develop future papers involving other faculty at Southern Connecticut State University so they may carry on the model for the Expert Systems course should they

choose to teach it in the future. He also plans to continue to honor individuals who have contributed to the computer industry so MIS students may have heroes.

- IT IS POSSIBLE TODAY TO CREATE AN EXPERT SYSTEM FOCUSED ON A SPECIFIC INDIVIDUAL RECOGNIZED AS AN EXPERT IN MANAGEMENT IN THE COMPUTER INDUSTRY.
- CERTAINLY, MARISSA MAYER IS AN EXCEPTIONAL TALENT WHO HAS HAD A SUCCESSFUL WORK CAREER.
- WHEN YOU HAVE BEEN BLESSED WITH SUCH TALENT AND ARE ABLE TO USE IT EFFECTIVELY, YOU ARE INDEED AN EXPERT IN YOUR FIELD AND A ROLE MODEL TO OTHERS IN THE COMPETITVE COMPUTER INDUSTRY.

Figure 5: Conclusions

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An Expert System of Marissa T. Barra's Knowledge (CEO of General Motors Corporation)

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Abstract

This paper describes the conceptual development of an expert system to advise those considering the top level position in a firm based on the expertise of Mary T. Barra. Mary T. Barra was promoted to the CEO position in 2014 during a very difficult time when General Motors was under-the-gun for cover-ups of defects in their automobile models which had caused death and had multiple law suits against the company. She faced the challenge head-on and began to change the culture of this hundred year old firm. She has become a role model for female college students that it is possible to reach the top level position formerly dominated by males. She qualifies for the model developed by the authors to recognize female industry managers as potential experts for a computerized expert system.

1. Introduction

Since the early 1980s expert systems have been developed for the purpose of passing expertise from those with the knowledge to those who need the knowledge in a convenient and easily accessed manner. The idea is to tap the mind of the expert such that a less expertise person can solve problems normally handled by the expert without the expert having to be present. In the early 1980s, expert systems were crude, self-developed by only a few firms that saw value in them. By the late 1980s, special languages such as VP-Expert and CLIPS emerged and software shells developed to increase the ease of development of these systems. The first decades of the 21st century has witnessed the emergence of intelligent expert systems which provide access to multiple experts within a narrow field of interest.

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Systems continue to become more complex but require constant upkeep.

This paper returns to the original concept of capturing the knowledge of a single expert in management. It is developed for student use to recognize heroes who have made significant contributions. It is a jointly written paper by two MIS professors as a continuing series of expert systems for a course in expert systems taught at SCSU.

This model has been useful in the classroom for the "Expert System" course for students to select their own expert and design such a system for that expert to better understand the nature of these complex systems. One student, Dana Mares, continued her project into an independent study course where she coded her work in CLIPS to demonstrate that the model be used to build an actual system if an appropriate language is used.

ADDITIONAL BACKGROUND TO PAPER

Since early 1990s, an elective course in the MIS program at SCSU titled "Expert Systems" has been taught periodically. In MIS work, expert systems have long been considered the most difficult and complex of all information system types. They are included in the family of applications known as "artificial intelligence". They represent an application attempting to mimic the human brain. These applications capture the experience of an "expert" in a narrow area of expertise in computer 2 form such that this vast "knowledge base" can be used to produce advice for a non-expert to solve a problem to which they have not gained appropriate experience as if they were equal to the expert. This is quite a challenge. Students were having difficulty understanding the nature of these systems and how they differ from traditional information systems from a design standpoint. Figure 1 outlines the components of an expert system.

- Dialog Screen – Determine Nature of Problem
- Knowledge Base – A collection of "If ...Then" statements From Experts
- Inference Engine – Software to search knowledge base
- Presentation – Determine how to display advice to system user

Figure 1: Components of an Expert System

For several years in the 1990s, expert systems had fallen out of favor in business because they had been incorrectly applied to the elimination of experts, who were usually the highest paid workers in an organization outside of the managers. However, with the downsizing of the early part of the 21st century, expert systems have reappeared as a training tool for such businesses.
In support of this course, which was the most challenging MIS course to teach, Dr. Mullen developed a model of an expert system to demonstrate to the students how such a system is developed using a language, CLIPS. The model involved picking two individuals a year who were experts in their field and who were living at the time so theoretically they could have been interviewed personally to capture their expertise. However, these chosen individuals were well known enough in their field to have had books and later Internet articles published about them. This was the source of information for these systems. Dr. Mullen began presenting his work at various conferences for peer comments to improve the process. A list of organizations where these papers have been presented and published is shown as figure 2 below. Since 2003, the focus of presentations has been the IEMS Conference held each March in beautiful Cocoa Beach, Florida when the weather in Connecticut has reached its peak of winter cold and snow.

Association of Management
Decision Science Institute
Industry, Engineering, and Management Systems
Information Resource Management Association

Figure 2: Conferences where expert systems papers were presented

Dr. Mullen also began to utilize the model to recognize the many contributors to the advancement of computer application usage who may be seen as heroes or role models to my MIS students. Such individuals who have had prior models developed of the expertise in the computer field include Bill Gates (Microsoft); Paul Allen (Microsoft); Steven Jobs (Apple Computers); Michael Dell (Dell Computers); Lawrence Ellison (Oracle); Scott McNealy (Sun Microsystems) and in 2011 Mark Zuckerberg, founder of Facebook, Steve Wozniak (co-founder of Apple computers). A co-author, Dr. Richard Bassett, was added this year as a co-author to assure the model did not die off with the retirement of Dr. Mullen for future presentations at IEMS conferences.

BACKGROUND OF MARY T. BARRA FEATURED IN THIS PAPER

Mary T. Barra was born in Waterford, Michigan on December 24, 1961. She graduated from the local high school in 1993. She graduated with from General Motors Institute (Now Kettering University) as an electrical engineer in 1985. Later, she earned an MBA degree from Stanford University. She joined GM right out of college and has a thirty-five-year career there. The focus of this paper is to recognize Mary T. Barra's contribution to the field of management. Mary T. Barra began her work career as an engineer but soon moved into various managerial positions culminating with a plant manager position at Hamersack's GM plant and a VP position appointment by an interim CEO as GM came out of bankruptcy in 2013. For this paper, Figure 3 below summarizes the management philosophy of Mary T. Barra.

1. Considered a hands-on manager known to visit dealerships and talk with customers directly.
2. She is focused on the company becoming "defect free".
3. She wants no more cover-ups and encourages employees to report anything they see as wrong.
4. She fired 15 employees involved in the old culture at GM known as "GM Nod".
5. She believes in worker balance in their lives to enjoy their families and leisure time. She is a focused worker but not "married" to her job.
6. She is known for the quote "no more crappy cars".

Figure 3: Management Philosophy of Mary T. Barra

SPECIFIC DEVELOPMENT OF THIS PAPER

During the Fall 2010 semester at Southern Connecticut State University, Dr. Mullen offered the course in Expert Systems that had not been taught for five years due to lack of support from the students. It had now been advertised as an elective for both MIS and management students. Students were asked to work on a term project that required selecting an expert in a field of interest to them. Most chose sports figures or well-known managers. One student selected Mark Zuckerberg with an interest toward developing the social network system into a target marketing tool. Dr. Mullen had planned to do a paper on Mark Zuckerberg for the 2011 IEMS conference that year so got permission to combine their work into a single paper for the IEMS March 2011 conference. This also stimulated Dr. Mullen to return to his original model of using these papers to recognize the many contributors to the highly successful computer industry such that future students of the course may continue that effort rather than focus on well-known sport's millionaires. At 2012 IEMS conference, the subject was Paul Allen as co-founder of Microsoft. At 2013 IEMS conference, featured Steve Wozniak, co-founder of Apple. Dr. Mullen did retire in 2013 but continues to teach as an adjunct, mostly on-line courses. The business school of Southern Connecticut State University is progressing toward AACSB accreditation which requires adjuncts to continue to do research and

present results at conferences with peer review. This generated a new focus of female executives as

previously unrecognized contributors to the computer industry in particular or managerial ranks in other industries. Dr. Richard Bassett co-authored this paper regarding Mary T. Barra as an expert system model's focus for 2016 IEMS conference.

In developing an expert system, a knowledge engineer asks questions of an expert in order to build a knowledge base. Figure 4 contains some example questions that would be appropriate to ask of Mary T. Barra to simulate the collecting of her knowledge in the form of advice for anyone interested in managing in the fast paced computer industry. Of course, we did not have an opportunity to actually meet with Mary T. Barra herself. With appropriate funding, cooperation, and time, it would have been possible to do so for the conceptual model development. But, we could uncover such situations from publicly published material via the Internet.

The language of an expert system is usually rule-based so that advice is shown as the answer to an "IF" question that the expert system user might have as a problem. Most of the advice from Mary T. Barra deals with her managerial philosophy. Yahoo now faces additional challenges in reorganizing itself into a profitable organization by spinning off some holdings as separate companies.

- IF your goal is to cover-up your mistakes, THEN your work ethic does not fit with the new GM.
- IF you are not willing to work smart, THEN GM is NOT the right choice for you.
- IF you are not interested in a balance life between work and family, THEN GM is NOT the right choice for you.
- IF you do not take pride in the work you do or the products you produce, THEN GM is NOT the right choice for you.

Figure 4: Mary T. Barra's advice on managing in industry

This paper describes the conceptual development of an expert system to capture the knowledge of Mary T. Barra. Figure 5 depicts the conclusions reached from the writing of this paper.

In the reference section at the end of this paper are other similar papers in the series of expert systems on computer or management professionals known to be experts in their field. Although Dr. Mullen retired in 2013 and does not expect to teach the Expert System course at Southern Connecticut University, there is value to continue this series of papers for IEMS. Dr. Mullen will develop future papers involving other faculty at SCSU so they may carry on the model for the Expert Systems course. He also plans to continue to honor individuals who have demonstrated managerial leadership or a significant contribution to the computer industry so that MIS and Management student majors may have their heroes.

- IT IS POSSIBLE TODAY TO CREATE AN EXPERT SYSTEM FOCUSED ON A SPECIFIC INDIVIDUAL RECOGNIZED AS AN EXPERT IN MANAGEMENT.
- CERTAINLY, MARY T. BARRA IS AN EXCEPTIONAL TALENT WHICH RESULTED IN HER SUCCESSFUL WORK CAREER AS A CEO.
- WHEN YOU HAVE BEEN BLESSED WITH SUCH TALENT AND ARE ABLE TO USE IT EFFECTIVELY, YOU ARE INDEED AN EXPERT IN YOUR FIELD AND A ROLE MODEL TO OTHERS PLANNING TO BECOME MANAGERS.

Figure 5: Conclusions

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Sentiment Analysis for Colloquial Arabic Extraction from Social Networks Opinion Posts

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Abstract

Sentiment Analysis is the process of distinguishing the contextual polarity of text. In other words, it decides whether a piece of writing is positive, negative, or neutral. As a result of the rapid increase in using Arabic language and the volume of opinionated Arabic posts shown in different social media, i.e. Facebook, the request for Arabic sentiment analysis tools increased. Social media posts, especially those made by adults, are usually written using colloquial slang Arabic, which many of them grow over time. Many research papers have been carried out to build modern standard Arabic sentiment lexicons. This needs to be accompanied by dialectical terms and continuously updated with slang. This paper proposes a fully sentiment analysis for colloquial Arabic extracted from social networks opinion posts, and improves the accuracy of results to reach the percentage of about 94 % upon the number of lexicons indicated in data set. Thus, the larger data set, the better accuracy and the higher percentage we get. The most presented approach does not employ any such tools, allowing to be generalized across dialects with some minor modifications.

1. Introduction

As a growth of collaboration between the Arab countries and the other countries, many research papers have been done to study the Arabic language opinion. Recently, we have witnessed a massive growth in the use of microblogging services and social media sites across the world, especially in the Arab World. In 2012, Semiocast published a paper to expose that Arabic was the fastest rising language in social media and Twitter in 2011. Also, the Arabic language is considered as the 6th most used language in Twitter in 2012 (Semiocast, 2012).

A recent research done about the usage of Facebook across the world, places Egypt, with 16 million users, as the most Arabic speaking country with the largest number of Facebook users. Also, it ranks Egypt as the 17th country in the world. This is a growth of 41% in terms and expressions of users from the preceding year (Farid, 2013). Both Twitter and Facebook are categorized by having a high percentage of highly opinionated posts between adults. The occurrence of such large amount of opinionated data highlights the need for sentiment analysis tools and resources. Sentiment analysis can be used in different areas like marketing and politics. Subsequently slang and dialectical terms and expressions are frequently used for expressing sentiments and opinions on different social media such as Facebook and Twitter. The aim of this work is to present an approach for capturing dialectical

or slang terms, or compound expressions that are extremely indication of subjectivity and also assign their polarity.

This paper is organized as follow: Section 2, describes the different aspects of the problem that this work aims to address. Section 3, briefly reviews the related work. Section 4, provides an overview of the proposed system. Section 5, presents the experiments carried out to evaluate the work and it's results. Section 6, shows conclusions.

2. The statement of the problem

The language that people use to express their feelings, opinions, and sentiment is tremendously varied. The research that deals with sentiment analysis in Arabic, is very limited. The sentiment analysis of Arabic social media is a very important issue not only because social media's language has a lot of colloquial Arabic, compound terms, expressions, idioms, and a lack of resources, as detailed in (El-Beltagy and Ali, 2013), but also the language used in social media, Facebook, and twitter has been used to be extremely dynamic evolving nature (Volkova et al, 2013). Inspired expressions and terms that imply subjectivity are often created on the fly by popular tweeps (twitter users) then quickly propagated and widely employed by other social media users. As a result, they become strong subjective clauses.

Subjective terms often emerge from peculiar exchanges observed on TV shows, advertisements, or directed YouTube videos. For example, the word "اووووة" "Ohhhhhh", and many other similar words, which has no meaning in colloquial Arabic or Modern Standard Arabic (MSA), is used frequently to specify a positive sentiment. Political circumstances and situations are still another sources of motivation for the establishment of modern expressions and terms which indicate high subjectivity (Elsahar and El-Beltagy, 2014).

Also, in this paper the authors deal with another famous problem which is the wide usage of English in translation to reflect positive, negative, or neutral sentiment. This work is able to pick up words like "وسيم Waseem" and "كيوت /kjuːt/" which both of them are Arabic translations of the English word "cute" which indicates a positive sentiment. In addition, this paper tries to capture the subjective slang and dialectical expressions and terms that are well established within a certain culture or country.

2. Related work

There hasn't been enough research dealing with slang detection, that allocating polarity to slang expressions. Nevertheless, if we consider slang as a distinct case of lexicon learning, a large amount of research becomes applicable. Research has been done to address the main issue of how to build a polarity lexicon for several included languages but not restricted to a specific known language such as Spanish, Chinese, Dutch, German, or English; the most remarkable language. This section, included in the paper focuses mainly on a relevant research done in Arabic language, which is the main target in this paper, and in English language, where most of the work was done and condensed.

SAMAR (Elhawary and Elfeky, 2010) challenges the problem of sentiment analysis in social media, Facebook, and Twitter from a frequently linguistic viewpoint. This new system is based on a high performance classification, supports vector machine (SVM) and carries out Semantic orientation (SO) determination in only two steps: the first step, the classifier is used to differentiate between subjective and objective cases. The second step, determines whether the subjective input carried out by another classifier is positive or negative. The main disadvantage is the neutral and mixed cases which are not solved by the system. The system used dataset which consists of 3015 Arabic terms which are divided into 1466 term written in MSA, and 1549 tweets written in diversed dialects to evaluate the dialectical performance of the system.

An approach for building the subjective lexicons of English language with scarce resources was presented (Banea et al., 2008). This approach depends on the seed of the word and needs a small seed of subjective words, plus the use of a

dictionary, to create a set of other subjective terms. These subjective terms are ranked using Latent Semantic Analysis as a similar measure between the created and the original seed, that is applied in Romania. This approach is unable to handle slang, which is very common in the most recently used social media, i.e. Facebook, as it can seldom be found in language dictionaries and totally disregards multi-word expressions, which are mostly used in Arabic language to deliver sentiment.

An approach for building a large scale Arabic sentiment lexicon was proposed (Abdul-Mageed and Diab, 2012). In this approach, they expand on a Modern Standard Arabic (MSA) polarity lexicon of about 3225 adjectives which were made manually by using several numbers of current English lexicons including SentiWordNet (Esuli and Sebastiani, 2005). Also the researcher deals with the coverage and the quality of some entries, otherwise the authors didn't test the system for the task of sentiment analysis. Also, this approach is still unqualified to cover slang, dialectical Arabic language, and multi-word expressions.

In 2010, another technique used a graph propagation for building a polarity lexicon over a phrase similarity. This graph propagation was built using 4 billion unlabeled web documents and a group of seed terms which were presented (Velikovich and Blair-Goldensohn, 2010). The results of work and experiments were done to show that the resulted lexicon develops the precision of the sentence polarity classification task. Learning slang and multi-word expressions is the main benefit of using graph propagation.

4. The proposed approach

As mentioned before, the main goal of this paper is to find an approach for detecting the commonly used dialectical or slang terms that reflect subjectivity. A term in that context of this research can be made up of a single word or multiple words. This approach consists of two phases and goals to classify the polarity of detected terms. Candidate subjectivity terms are detected and determined in the first phase. In the second phase, they are classified to detect subjective words/expression greatly. After that, we need to identify a set of lexico-syntactic indicative patterns of subjectivity. At this point, the use of handcrafted patterns is not a novel idea in the context of information extraction as mentioned by Hearst (Hearst, 1992) who used them for acquiring hyponyms from enormous text corpora, however Klaussner and Zhekova (Klaussner and Zhekova, 2011) used them for ontology learning.

In addition, the tags used in this research within the proposed patterns do not require the use of a part of speech tagger. Actually, each tag has a list of finite possible values that is a dialect dependent, conversely, the presented patterns are mostly dialect independent. The range of possible values, from which tags in a pattern can be derived, depends on the dialect that is being targeted. This research and experiments have studied Egyptian Arabic language focusing on talking and chatting on social media, Facebook and Twitter, and more dialects, specifically the Cairene dialect.

In the first phase, the extraction patterns are applied on a large corpus/body of the text obtained from Twitter and Facebook to yield a set of subjective terms. In the second phase, the extracted terms are based on the normalized point wise mutual information score, and positive and negative terms derived from an existing polarity lexicon. The details of these two phase are presented in the following subsections.

4.1 Patterns' extraction

This algorithm works on finding the sentiment analysis in colloquial Arabic extraction from social networks opinion posts and classifying sentences into two types: positive or negative. It is used for determining the polarity of user's opinions in social media. It depends on trying to find the relation between words and different compounds which are found in the opinions to get a more accurate decision based on the results.

Algorithm technique:

Preprocessing: instead of using the sentence as a whole, we apply a classification process with

opinion, which splits each sentence into sub-sentences, as shown in figure 1, based on Arabic delimiters which give different meaning for each sub-sentence that is almost unrelated to each other such as "و", "لكن", "لذلك", "لان", "إن", "أن", "حيث", "بسبب", "علشان", "بس", ... etc.

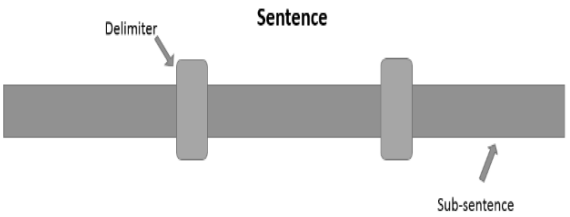

Figure 1 splits each sentence into sub-sentences

The problem occurs a lot when the delimiter "و" is connected to the next word. It is considered as a single word then "و" here is not considered a delimiter as shown in figure 2. We solved this problem by using the "Arabic Stemmer" when we find any word that starts with the character "و". It stems the word and gets its source, then compares the first character in the source with the "و" character. If the first character is "و", the character "و" in the word will be original. Thus, if the first character is not "و", the character "و" will be a delimiter and won't be original; it separates the character "و" from the word.

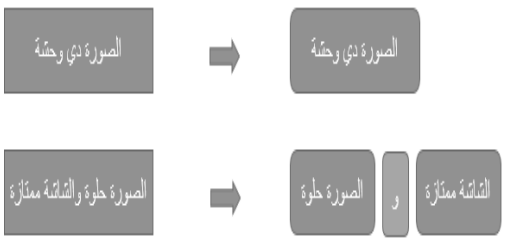

Figure 2 delimiter connected to the next word

- Although the "Arabic Stemmer" is useful to revert all words to their sources and not to use all the derivatives of each word, it has many problems:

1- It stems most of neutral words whose source can be positive or negative. For example, the word "السعر" is neutral but "مسعور" is negative. Both of them has the same source "سعر". This causes a big problem where it counts the neutral word as a negative word and therefore changes the results.

2- There are some positive and negative words which are similar in shape and source; the word "فشيخ" is positive but "اتفشخ" is negative. Their source "فشخ" is the same, despite. This leads to count the same word once as a positive word and once as a negative one.

3- There are some positive or negative words which have one or more repeated letters that the stemmer cannot stem; such as the word "جاااااااااااااااامد" is positive and it can make a distinction in the meaning.

- We could overcome all these problems by using a limited number of the derivatives of positive and negative words and by removing the repeated letters.

- We found that when a lot of words come with other words, they change the meaning of the sub-sentence to 180 degrees. So we were trying to find a new rule that matches all expressions and patterns when we found that applying the mathematical logic concept is a more general rule and matches almost all expressions and patterns

- We consider that each sub-sentence is independent from the others, so we apply the mathematical logic concept, as shown in figure 4, on each sub-sentence and the result is calculated for each sub-sentence. After finishing the calculations of all sub- sentences, the final result is calculated by gathering the result of sub-sentences and counting them to get a single sign. As a result, we determine if the sentence is positive or negative.

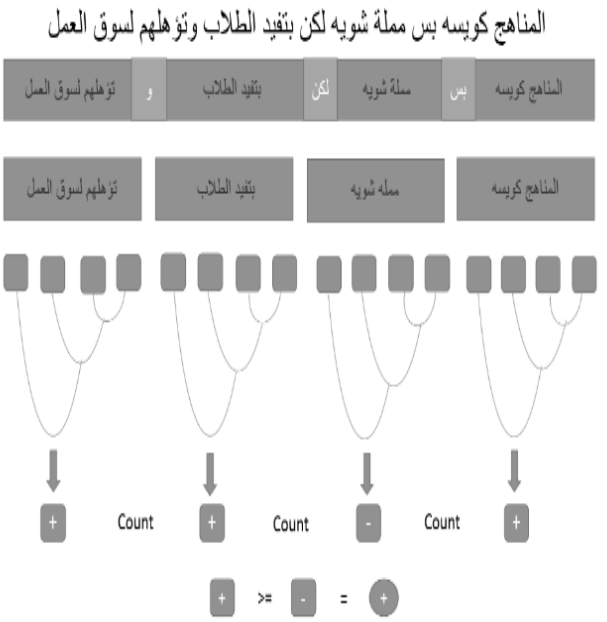

Figure 3 example of the steps applied on the approach

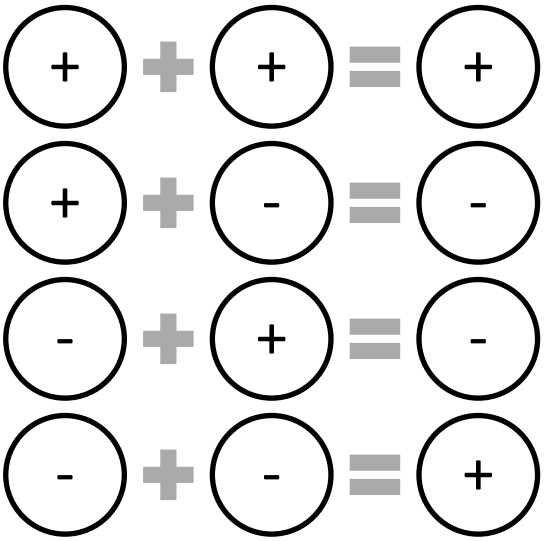

Figure 4 mathematical logic model

4.2 Polarity classification

There will be a need for allocating polarity to terms/expressions, after extracting candidate subjective terms. To do this allocating, this research proposes the use of co-occurrence statistics between each of candidate in a large group of microblogs or tweets. The reason for doing this process in a microblog or tweet is chosen as a unit of information instead of a whole document or a longer posting, is that the short nature of tweets. In addition, tweets are rich with slang. Co-occurrence can be evaluated using normalized point wise mutual information *nPmi,* by tagging single tweets in a big corpus using current sentiment lexicon (Xu and Croft, 1998; Elsahar and El-Beltagy, 2014) as represented by the next equation, where *x* represents the candidate subjective term and *y* represents the polarity class which can be positive or negative.

$$nPmi(x,y) = \left(\ln \frac{P(x,y)}{P(x)P(y)} \Big/ -\ln P(x,y) \right)$$

5. Experiments and Results

In order to know whether the presented approach is able to accomplish its aims or not, the presented designs have to be applied on a large corpus in order to extract terms. We need to calculate the percentage of precision, as shown in figure 5, and recall, as shown in figure 6. After that, we calculate the F-Measure in order to know the percentage of the convergence. Then the extracted terms have to be annotated and allocated with polarity. Also, the system's capability to extract subjectivity and slang and its capability to allocate polarity were calculated by calculating the F-Measure. In section 5.1, we describe and present the dataset examined in the experiments. Section 5.2, shows the results of our approach.

5.1 The used data set

In order to build the corpus to apply this work, a set of a large number of Arabic language tweets is obtained using the twitter API. Then the initial step is applied on individual tweets to remove

undesirable features and noise. The process includes the same technique which is used in the research done by Elsahar and El-Beltagy in 2014 by removing the hyperlinks, then removing the hash letter '#' to capture subjective text, then do a text normalization. Finally, we remove the redundant tweets (Elsahar and El-Beltagy, 2014; Larkey et al., 2007; Singhal, 2001).

5.2 The results

Number of comments tested: 50
Expected results:
Positive = 32 comments with 64 %
Negative = 18 comments with 36 %

Actual results:
Positive = 31 comments with 62 %
Negative = 19 comments with 38 %

Evaluation
Positive Comments
A = 31, B = 1, C = 0
Precision = 31/31 = 100%
Recall = 31/32 = 96%

Negative Comments
A = 18, B = 0, C = 1
Precision = 18/19 = 94.7%
Recall = 18/18 = 100%
F-Measure = 2*(94.7*100 / (94.7 + 100)) = 97.3%

6. Conclusions

In this paper we have presented an approach used for analyzing colloquial Arabic extraction from social networks opinion posts, by improving and evaluating the ratio of every word using the F-Measure to distinguish the percentage of positive to negative precisely. The results of experiments done in our approach, that worked and tested Egyptian Arabic language, show that the approach is able to detect subjective internet slang in social media, Facebook and Twitter, that is represented by only one word or by several words as a whole sentence, as well as classifying the polarity of these subjective terms with a high degree of accuracy.

Acknowledgement

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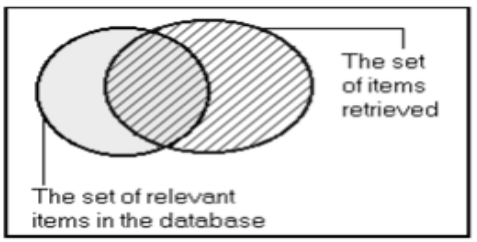
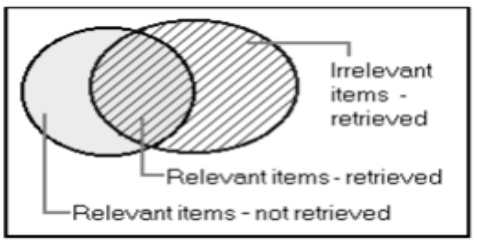




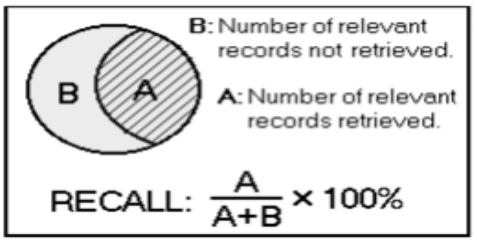
Precision and **recall** are the basic measures used in evaluating search strategies.

As shown in the first two figures on the left, these measures assume:

There is a set of records in the database which is relevant to the search topic

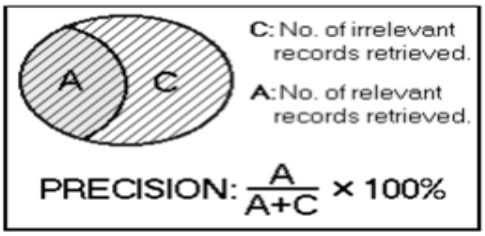
Records are assumed to be either relevant or irrelevant *(these measures do not allow for degrees of relevancy)*.

The actual retrieval set may not perfectly match the set of relevant records.



RECALL is the ratio of the number of relevant records retrieved to the total number of relevant records in the database. It is usually expressed as a percentage.

Figure 5 recall calculation



PRECISION is the ratio of the number of relevant records retrieved to the total number of irrelevant and relevant records retrieved. It is usually expressed as a percentage.

Figure 6 precision calculation

Teaching Engineering Mechanics – Statics with Working Model Simulation

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Rochester Institute of Technology

Abstract

This paper document recent innovation in teaching Engineering Mechanics--Statics with Working Model Simulation which makes a significant improvement in teaching Engineering Mechanics--Statics and provides a better learning environment for mechanical engineering technology student at Rochester Institute of Technology. The use of Working Model Simulation with analytical solution in Engineering Mechanics--Statics provides more opportunities for mechanical engineering technology student to experiment conceptually and to explore new alternatives to the Engineering Mechanics--Statics problems with quick response and minimum effort. The use of Working Model Simulation in teaching Engineering Mechanics--Statics allows our students a clear insight to the mathematical model of Engineering Mechanics—Statics. Case studies of Working Model Simulation with analytical solution in Engineering Mechanics--Statics are given in this paper.

1. Introduction:

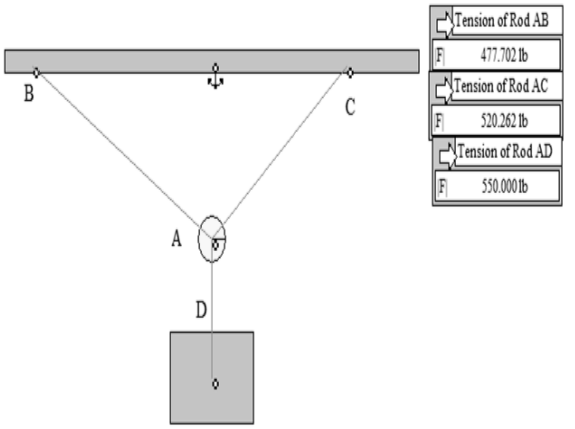
The subject of statics developed very early in history because it's principles can be formulated simply from measurements of geometry and force. Statics is the study of bodies that are at rest or move with constant velocity. We can consider statics as a special case of dynamics, in which the acceleration is zero. But, the real life application of statics in structure and mechanical system require understanding and higher accuracy without any concept and calculation misleading.

Computer simulation based laboratories (CSBL) have successfully been used to promote conceptual change in mechanics. In CSBL-labs students do virtual experiments and taking advantage of the real-time display of the experimental results facilitates conceptual change by the computer. Thus students' alternative conceptions can successfully be addressed. Acquiring a conceptual understanding of mechanics has proven to be one of the most difficult challenges faced by students. Studies by many different researchers have shown that the misleading conceptions about the nature of force and motion, which many students have, are extremely hard to overcome. Research has shown that traditional instruction does very little change students' "common-sense". In a CSBL Based Laboratory, students do virtual simulation experiments and compare with analytical solution.

The Working Model 2D software is used to create and model of the system and simulate the statics behavior of the system and to verify the analytical solution. Case studies of Working Model Simulation with analytical solution in Engineering Mechanics--Statics are given in this paper.

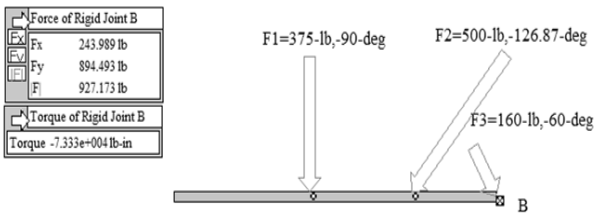
Case Study 1. Simple Truss Force Analysis

Problem F4-1. Determine the forces in each supporting cables.
1. View-Number & Units-Unit System-English(lb)
2. Draw a crate 20x30-in and 550-lb with coord (0,0)
3. Draw a ring A with radius R=5-in with coord (0,20)
4. Add a ceiling with size (5, 150) and coord (0,70) on the top of ring
5. Add three cables AD,AB, & AC with given inclined angles 90, 150, and 36.87-deg respectively.
6. Measure the tension forces in cables and run simulation
7. Double check by analytical solution.

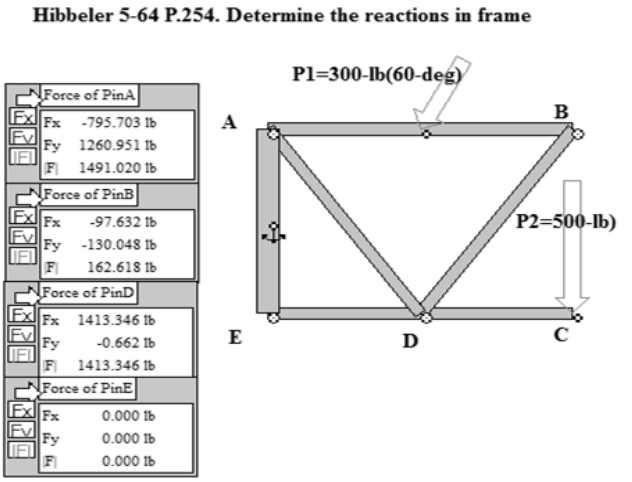


Case Study 2. Find the Reaction forces and Moment at the Fixed End of a Cantilever Beam

Problem 3-4 & 3-5, Cantilever Beam with Fixed end B and three forces F1,F2,& F3. Measure the reaction forces and moment at Point A or Point B with each force and force system.
1. View-Number & Units-Unit System-English(lb)
2. View-Workspace-Add Check mark in front of Navigations
3. Draw a beam 6x228-in with x=114, y=-3-in in Property Window,
4. Fixed at A (0,0) with rigid joint
5. Add three point elements at (-18,3),(54,3),&(-114,0) which are corresponding to the mass center of beam.
6. Add three forces at the above points with force scale 0.00003,
F1(375-lb,-90-deg),F2(500-lb,-126.87-deg),F3(160-lb,-60-deg)
7. Deduce the weight of beam to 0.1-lb,
8. Fixed Point A (0,0) or Point B (114,0) with Rigid Joint and measure the reaction forces and moment about Point A or B.
9. Double check by analytical solution.

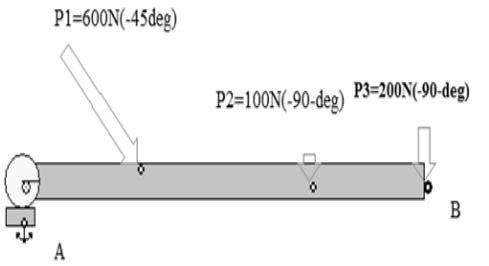


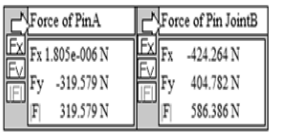
Case Study 3. Forces in a Given Frame



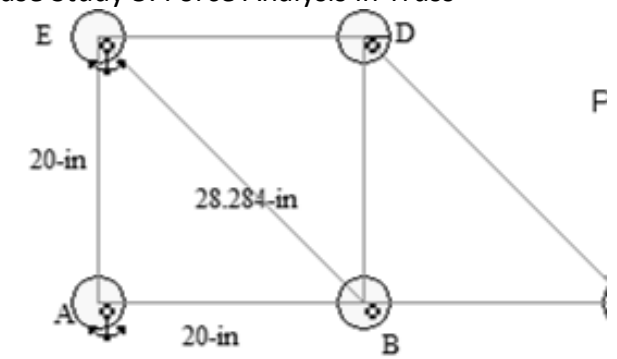
Case Study 4. Reaction in a Simply Supported Beam

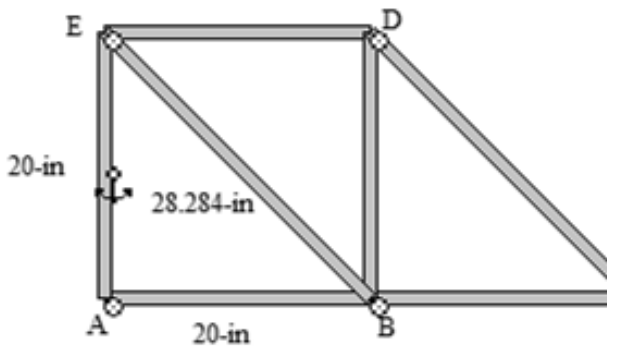
Hibbeler Example 4.5 P.154 Beam in WM2D-- 1. Design a beam 0.4x7-m (m=0.01-kg) 2. Pin Joint at pt.B 3. Add a roll at pt.A with R=0.3-m. m=0.001-kg 4. Add a block 0.2x0.5-m under the roll. 5. Add forces 600N(-45-deg), 100N(-90-deg), and 200N(-90-deg) as shown, which is 2m, 5m, and 7m from pt.A 6. Measure the reaction forces at A and B and run simulation.





Case Study 5. Force Analysis in Truss





2. Conclusions:

The simulation in Working Model 2D is a real life simulation. For example, the weight of each part of the system can be very small, but can't be eliminated. If, the system with spring or other elements with stiffness, the equilibrium equations are given after deflection. Where in regular statics analysis, the deflection of the system is neglected. This is the first step research of how to use a dynamics simulation tool-- Working Model 2D to simulate a statics system. There are many interest stories, we could find from the future development.

Bread & Roses Kitchen Live Case Study

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Abstract

Small businesses make up the majority of the business community in the United States. Small, locally owned institutions contribute greatly to the economies of the communities they operate in. Improving the capacity of these businesses to operate efficiently can result in financial, social, and economic benefits. The focal point of this project is a small, locally-owned (Tallahassee, FL) food business. After conducting primary research into the components of the business' supply chain, we will utilize the ProModel 2011 software to develop a computer model to simulate the logistics operations. Using this logistics model simulation, we make recommendations to the business with the intent of optimizing the supply chain, minimizing cost, improving customer satisfaction, and increasing overall utilization and efficiency. The supply chain components that will be researched, analyzed, and simulated include a raw material supplier, a manufacturer, a distributor, a retailer and a population of customers.

1. Summary

Bread & Roses is a restaurant and grocery store located in the heart of College Town and managed by volunteers. Each volunteer has an equal share in the co-op. By operating the store in this manner, overhead and expenses are kept to a minimum. Bread & Roses supplies shoppers with fresh, locally grown produce and household items.

2. Overview

Bread & Roses Kitchen (BRK) is a LLC registered in Tallahassee, Florida and is located at 915 Railroad Ave, in the heart of what is known as 'College Town'. BRK is a vegetarian/vegan café that prides itself on serving fresh, natural, and often local products to its customers. BRK is associated with the Bread & Roses Food Cooperative (BRFC), a group with which it shares a facility as well as resources. The Café is 2.5 years old and the cooperative is 6 years old. The dichotomy of the relationship between the cooperative and the kitchen is important to understand.

Bread & Roses Food Cooperative operates a natural food grocery store in the same facility as Bread & Roses Kitchen. It is a member owned non-profit and is staffed completely by volunteers. In exchange for a small fee and 3 volunteer hours a month, co-op members are granted a share of the cooperative, making them an owner, as well as access to discounts on the grocery items located in the store. BRK and Bread & Roses food cooperative share the same lease, and in many instances, other resources as well. These other resources include customer base, target market, inventory, and at times, staff.

3. Competitive Environment

As mentioned, the company is located on Railroad Ave. in Tallahassee, Florida. The location is directly between Florida A&M

University and Florida State University within walking or biking distance for students from both universities. Together these universities have about 51,600 students. These students comprise Bread and Roses' target market.

The restaurant is also a short drive from downtown and many working professionals can quickly make the drive to the restaurant for its vegan/vegetarian dishes. Bread & Roses also offers amenities similar to a lounge or coffee shop, making it an attractive location for people that enjoy those types of environments. The restaurant allows people to relax and even do homework while enjoying a fresh brewed coffee or even beer. The atmosphere at Bread & Roses Kitchen is similar to some of the surrounding restaurants. These restaurants include The Crepevine, ALL Saints Café, Wild Greens Café, Marinated Mushroom, and Starbucks. By providing viable substitutes for some of the services and products BRK provides, each of these restaurants provides significant competition which further segments BRK's target market.

4. Operations

At the Bread & Roses Food Cooperative, there are 12 volunteers designated as keyholders, who are present every week to open and close. These keyholders share added responsibility and are often involved with the administrative aspects of ensuring that the store operates properly. These added responsibilities include interacting with the Distribution and Ordering Team, which meets every Monday. Currently 3 long-time volunteers manage the majority of the cooperatives sourcing and procurement. Their responsibilities are split between distribution, local product sourcing, and local produce sourcing.

BRK does not utilize volunteers to staff the restaurant. Instead, at least 1 of the 2 owners is present on a daily basis and joined by two kitchen staff persons. At all times at least one of the owners is present to make sure that operations are flowing smoothly. The restaurant is open on Mondays and Tuesday from 11:00 AM - 8:00 PM and Saturday from 11:00 am - 3:00 PM.

Though they are separate brands, BRFC and BRK rely on the same set of suppliers. United Natural Foods Inc. (UNFI) serves as a primary distributor. A BRK staff person makes weekly trips to Tomatoland and Costco. The restaurant also sources, some of its food products from the Tallahassee Food Network. An order is placed once a week, typically Monday for fresh, locally grown products. Orders to BRK suppliers are placed once a week, a day in advance to companies that ship. Restocking products, which often requires physical visits to Costco and/or Tomatoland, tends to take about a 1.5 hour round trip. Sourcing needs vary based on demand and customer traffic, requiring additional interactions with suppliers and distributors.

5. Production Practices

BRK uses pre-preparation methods to stage ingredients for later use in its menu items. The activities included in pre-preparation or "prepping the line," as one of the owners calls it, include chopping vegetables for salads and other dishes so they can be easily accessed and added to a dish when a customer places an order. A flat top grill is used in the preparation of the majority of BRK's hot dishes. It is thoroughly cleaned twice a day at mid-day and closing time respectively.

Multiple menu offerings are also prepared prior to BRK opening for business. The 'sausage pappion' and Josephina burgers (two popular dishes) are fully prepared in the morning and stored in the freezer. These items are thawed in batches on a day by day basis, as needed. House made condiments and side dishes are also prepared prior to opening for business. These include BRK's vegannaise (vegan mayonnaise), roasted potatoes, the soup and quiche of the day, and BRK's fresh, house bread. The soup and quiche of the day are

made fresh daily; soup is stored in a crockpot to remain warm in anticipation of customer orders. Completed dishes and prepped additions are refrigerated as necessary and stored until needed to fulfill a customer order. Given these practices, BRK utilizes a first in-first out production philosophy.

Susy, Co-owner of BRK, states that an average order is fulfilled in 10-15 minutes. She agrees that the practice of pre-preparing certain food items and dishes saves a significant amount of time. This is especially important given BRK's peak hours of 12:00 - 2:00. Because these hours are often lunch breaks or class breaks for BRK's customers, it is imperative that service times are as short as possible. Suzy stated that if BRK did not "prep the line," service times would more than likely double.

6. Customer Interaction

Bread & Roses Kitchen's peak hours are between 12:00 PM and 2:00 PM. This is the time where many students and professionals are taking lunch breaks and they stop by the restaurant for lunch or a snack. Most customers stay around 45 minutes and are served within 10 minutes. Those who are not eating lunch and simply purchasing a snack or a drink can be served in less than 1 minute.

7. Data

After visiting Bread and Roses Kitchen on several occasions, we have observed several trends. Because the café is a target lunch restaurant, the peak business hours are from 12:00-2:00pm Tuesdays and Fridays. We visited the restaurant on both a Tuesday and Friday and our data support that. The minimum number of customers seen during lunch hours is one and the maximum is sixteen. It is confirmed that around 2:00pm, the restaurant slows down tremendously in business and very few customers patronize the business. As we continue to visit Bread & Roses Kitchen, we will observe and compare the number of customers and wait time.

In order to determine the proper distribution for the customer inter-arrival times and wait time in the queue, an analysis was conducted.

H_0: The data are exponentially distributed.

H_A: The data are not exponentially distributed.

The histogram in Exhibit A depicts the inter-arrival time distribution. Exhibit B provides a Chi-Square Goodness-of-Fit from which we conclude that the inter-arrival times are exponentially distributed

8. Promodel Simulation

In order to graphically depict the customer experience at Bread & Roses Kitchen and the relationship with their supply chain we conducted a simulation. We utilized the 2011 version of the simulation software ProModel (Harrell, et. al. 2004). The simulation enabled us to expand our study and predict the results of the business for a much larger interval of time. We recreated the process at the business by explicating the customer waiting area, the transaction counter, and the dining area. Our simulation inputs were based on the actual data collected during our observations, particularly the mean inter-arrival, transaction times, and the time spent in the queue. We also illustrated the supplier process, as Bread & Roses Kitchen received their goods from the four major distributors. The four suppliers are Tallahassee Food Network, UNFI, Costco, and Tomato Land.

9. Fourcast

We used the Fourcast (2016) computer program to forecast of U.S. gross domestic product. This was done in order to help better predict demand at Bread & Roses, an American company, and further improve its supply chain. The past GDP data that we used were the quarterly records dating back to 1947 (see Exhibit G). This history was used to predict the demand for the remainder of 2016. Exhibit F is

interpreted to mean that demand at BRK will increase in the same proportion. Exhibit G.

10. Results and Recommendations

Bread & Roses has a very efficient and reliable supply chain. So few links within the supply chain strengthens the reliability and results in a quick raw material to meal and then meal to customer flow. Customers do not have to wait long in the queue to receive meals and the restaurant does not run out of dining space. Through running the ProModel simulation we found that Bread & Roses Kitchen is not as profitable as the owner predicts. The simulation has revenue higher, although this was measured using peak times. The drawback is the cost of goods sold increase at a much higher percentage. Our recommendations are that the company purchase more products in bulk to take advantage of quantity discounts that are provided by its 4 suppliers. Bread & Roses Kitchen should also increase the cost of the average meal from 5 dollars to 7 dollars to increase revenue to $13,687. This will result in a profit of $3,769/ month vs. the loss that is currently being incurred.

11. Conclusions

Through speaking with the representatives at Bread & Roses we have gathered that this organization works very closely with its suppliers. Due to the fact that Bread & Roses Kitchen is a food organization they make purchases weekly and in some instances daily. We want to be able to maximize their distribution channel and increase efficiency in their business. We plan to develop a virtual simulation that models the customer visitation and supply chain of the organization.

Exhibit A

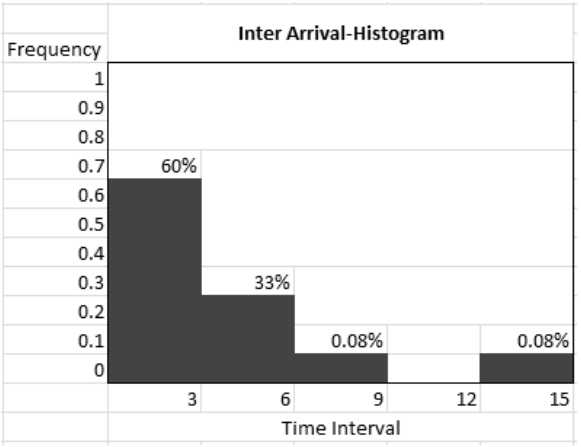


Exhibit B

Chi-Square Goodness of Fit Test for inter-arrival times

Cell *i*	Interval	O_i	P_i	E_i	$(O_i - E_i)^2 / E_i$
1	0-1.174	8	.333	6.33	0.441
2	1.175-3.18	4	.333	6.33	0.858
3	3.13-inf	7	.333	6.33	0.071

					1.370

Ho: Time inter-arrival times are exponentially distributed
Ho: Time inter-arrival times are not exponentially distributed
Since χ^2_{test} =1.370<$\chi^2_{1,0.05}$=3.841
Fail to reject Ho and accept that the inter-arrival times are exponentially distributed.

Exhibit C

Restaurant & Simulation Layout

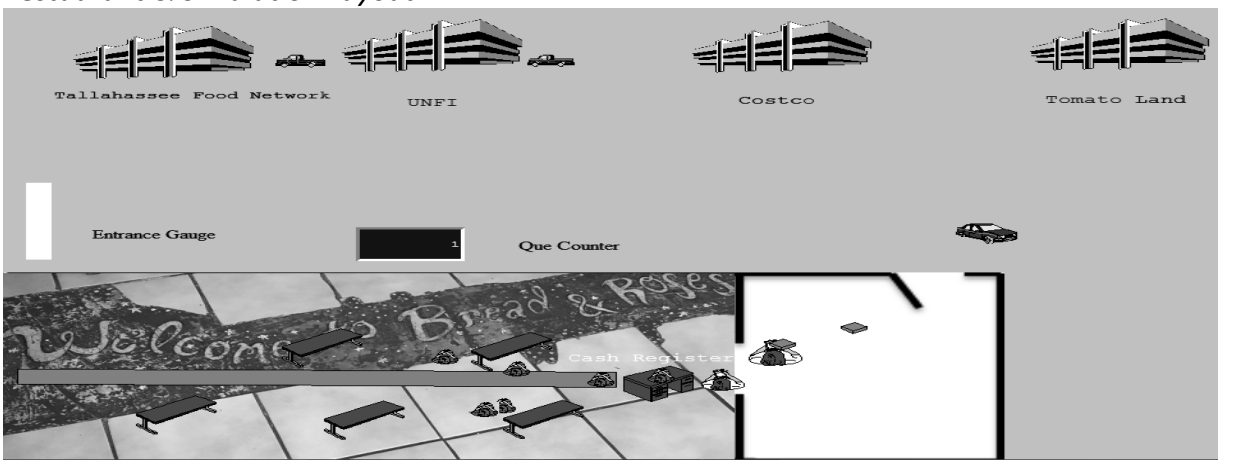


Exhibit D

Comparable Income Statements

Estimated Income Statement/month		
Revenue	$	10,815.48
COGS	$	(1,856.48)
Gross Profit	$	8,959.00
Operating Expenses		
Payroll	$	(4,496.00)
Rent	$	(900.00)
Sales Taxes	$	(811.20)
Utilities	$	(600.00)
Addional Overhead	$	(120.00)
Insurance	$	(125.00)
Total Operating Expenses	$	7,052.20
Income Before Taxes	$	1,906.80
Federal Taxes	$	(32.00)
Net Profit	$	1,874.80

Simulated Income Statement/ month		
Revenue	$	9,776.70
COGS	$	(2,833.85)
Gross Profit	$	6,942.85
Operating Expenses		
Payroll	$	(4,496.00)
Rent	$	(900.00)
Sales Taxes	$	(811.20)
Utilities	$	(600.00)
Addional Overhead	$	(120.00)
Insurance	$	(125.00)
Total Operating Expenses	$	7,052.20
Income Before Taxes	$	(109.35)
Federal Taxes	$	(32.00)
Net Profit	$	(141.35)

Exhibit E

2/11/2016 Data

Guest	Enter	Order	Receive Order	Service Time
1	11:33 AM			
2	11:38 AM	11:38 AM	11:49 AM	11 min
3	11:38 AM	11:40 AM	11:50 AM	10 min
4	11:52 AM	11:53 AM	11:53 AM	1 min
5	11:58 AM	11:58 AM	12:15 PM	17 min
6	11:58 AM	12:02 PM	12:15 PM	13 min
7	12:00 PM			
8	12:00 PM	12:02 PM	12:21 PM	19 min
9	12:00 PM	12:04 PM	12:21 PM	17 min
10	12:00 PM	12:04 PM	12:22 PM	18 min
11	12:00 PM	12:05 PM	12:23 PM	18 min
12	12:06 PM	12:08 PM	12:23 PM	15 min
13	12:06 PM	12:08 PM	12:23 PM	15 min
14	12:13 PM	12:13 PM	12:29 PM	16 min
15	12:18 PM	12:22 PM	12:34 PM	12 min
16	12:20 PM	12:23 PM	12:37 PM	14 min
17	12:20 PM	12:23 PM	12:37 PM	14 min
18	12:23 PM	12:25 PM	12:38 PM	13 min
19	12:26 PM			
20	12: 30 PM	12:31 PM	12:38 PM	7 min
Average				13.5 min
Key				
	Guest did not order			

Exhibit F

Forecast GDP projection

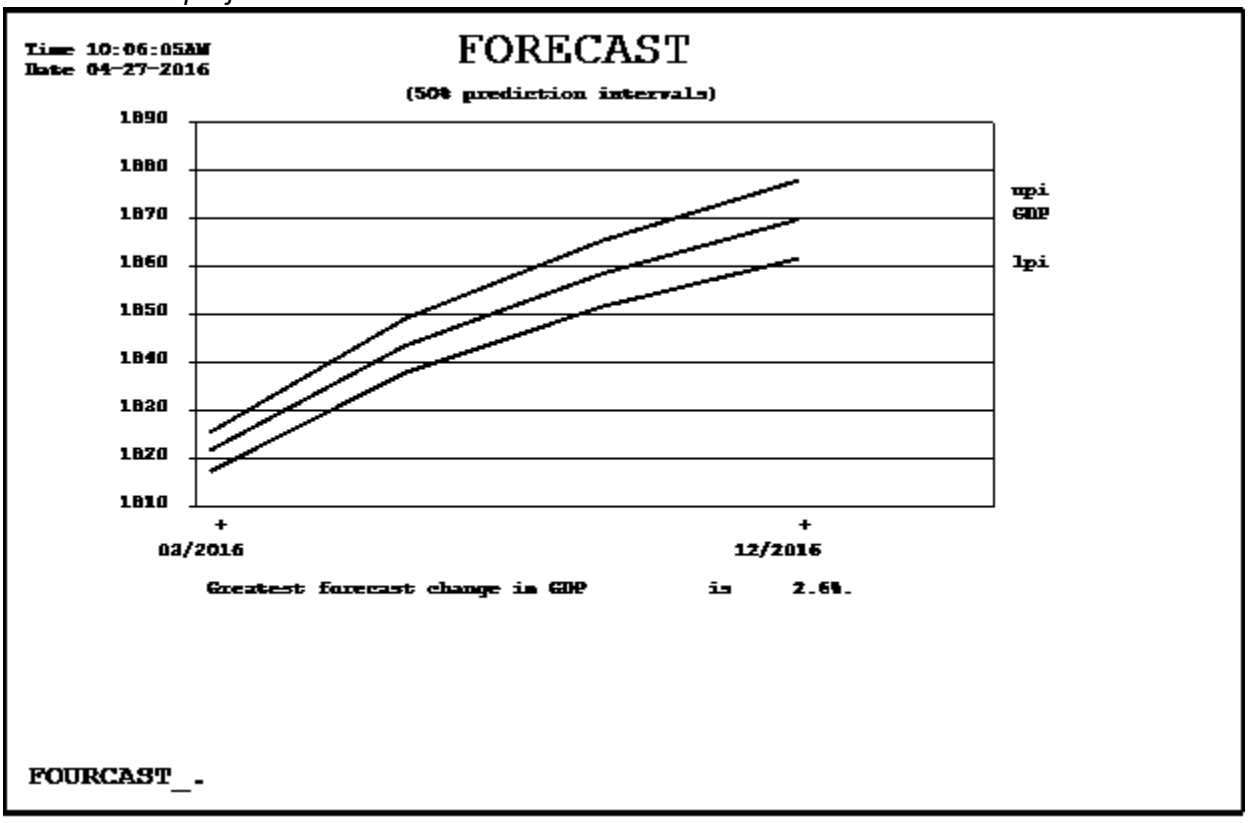
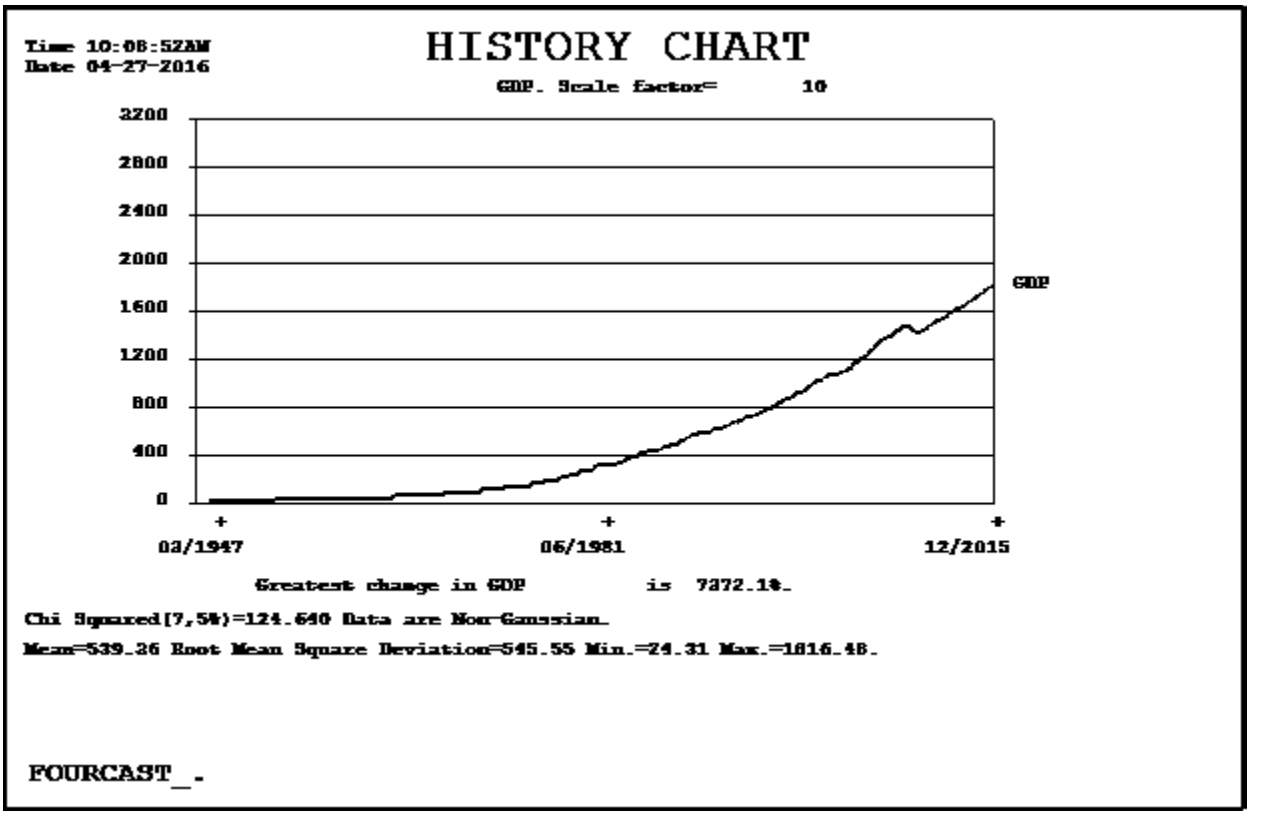


Exhibit G

Forecast Historical GDP



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Can there be a Collaboration of Leaderships Traits and Entrepreneurial Traits: An Analysis of Five Mutual Attributes for a Successful Alliance

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Abstract

Research shows that effective leaders share key characteristics such as risk acceptance, trust, vision, decision-making, and empowerment. Yet the opposite is also true, possession alone of these key characteristics does not guarantee success as a leader. If we extend our research to look at whether or not entrepreneurs share the same key characteristics as leaders, we find they share them all. In fact, there is evidence that suggests there is not much difference between the traits of entrepreneurs and leaders. And are these traits enough to build a vision, a mission and an effective strategic plan to implement? While there is consensus among academic leaders that there several schools of thoughts as to how individuals become leaders, there is no one school of thought that has emerged determining which approach is the foundation for success. This paper will look at various schools of thought and explore which traits are most likely needed for a successful alliance of entrepreneurs and leaders.

1. Introduction

While there is consensus among academic leaders that there are several schools of thoughts as to how individuals become leaders, there is no one school of thought that has emerged determining which school of thought dominates.

The great man theory of leadership [1] ascribes to the belief that leaders are born, not made. The traits theory [2] assumes there are certain inherent characteristics found in great leaders. The transformational theory [3] ascribes to the relationships between leaders and followers, which results in for exceptional performance and achievement of extraordinary results.

There is a similar consensus among academic leaders regarding entrepreneurial categories. The great person school supposes that entrepreneurs are born with special traits and instincts. The classical school believes that entrepreneurs are distinctively innovative and creative. The leadership school describes entrepreneurs as already being leaders who must have followers because they cannot accomplish their goals without being dependent on others.

Everyone recognizes that there are certain traits common between leaders and entrepreneurs, among them being risk acceptance and risk management, trust and vision. Also included are decision-making and empowerment. So, which Leadership School, if any, which Entrepreneurial School, if any, which trait or traits are most likely for a successful alliance of entrepreneurs and leaders?

2. Statement of the Problem

The conclusions we arrive at are completely dependent on the questions we ask as we attempt to resolve issues or solve problems. When researching an issue, the challenge is to ask appropriate questions. “The questions we ask often prevent us from asking other questions” [4]. Asking the wrong questions is fruitless and will produce results less satisfying than what is wanted. So we need to properly frame the questions to answer the real issues.

Can entrepreneurs be considered to be leaders by the very nature of the fact that they are pursuing ventures that are in uncharted territories and need to depend on others? Entrepreneurs need a well-defined vision and need to be able to transition that vision into a reality primarily by involving others in the process. Can it be argued that having a vision, bringing that vision to reality and a successful conclusion while involving others is not only entrepreneurship but also leadership [5]?

Risk taking is also another trait common to both entrepreneurs and leaders. Taking risk must also be balanced against managing that risk while being decisive. Making good decisions becomes critical and challenging. It is also imperative to consider both positive and negative aspects in the choices involved [6]. It is necessary to motivate and inspire followers while influencing and directing them while pursuing the goal. These individuals want definitive information about what must be accomplished rather than what could be accomplished [7]. Therefore, are leaders also entrepreneurs because of a common characteristic shared and practiced by both?

Identifying and defining common traits and attributes of both leaders and entrepreneurs is straightforward and uncomplicated. Analyzing those traits is also simplistic. The problem is to structure the formation of our queries in such a manner that it is impossible to deny the validity of our conclusions.

3. Literature Review

There are at least eight leadership theories referenced in academic literature and at least six entrepreneurial schools of accepted beliefs. The review of literature that informs this study was based on three commonly referenced leadership theories and three entrepreneurial schools of thought to provide a framework for comparative analysis. First, the review examined three basic leadership theories: great man theory, trait theory and transformational theory. Second, the literature that defines entrepreneurs, and the various types of entrepreneurs was reviewed. Third, attention was drawn to the relationships between leadership traits and entrepreneurial traits.

3.1 Great man theory

The great man theory of leadership is the oldest leadership theory that has been used for centuries. This theory is based on the premise that “great” men are born not made. Leaders differed greatly from followers and were born with innate traits that enabled them to be leaders. Among those traits were energy, intelligence and a moral compass enabling leaders to deal with complex situations [8].

In fact, within the writings of historical events “great men” are often referenced in relation to the noteworthy event. Current advocates of this theory discuss Lee Iacocca, John F. Kennedy, Martin Luther King, and Douglas MacArthur as examples of great men with those innate abilities.

3.2 Trait theory

Trait theory implies that effective leadership is a matter of selection [9]. It expands on the great man theory by focusing on the personal traits of great leaders. Many of the examples of great leaders were pulled from the pages of history such as Ford, Churchill, Roosevelt, Napoleon and Mussolini.

Although numerous studies were conducted to identify the traits, no obvious answer was found with respect to what traits are consistently associated with great leadership.

Disregarding the situational and environmental circumstances that play a role in the effectiveness of a leader was a critical flaw of trait theory [10].

3.3 Transformational theory

Transactional theory is often mistaken for transformational theory but the two are quite different. While transactional theory deals with specific activities, or transactions, between two or more people, transformational theory addresses how leaders influence followers through intellectual stimulation and individualized personal attention.

Transactional leadership is initiative based, contact is made based on the premise of an exchange of value. In contrast, transformational leadership is attempting to gain compliance of followers based on impacting the needs, beliefs and values of followers [11].

3.4 Great person school

The great person school states that entrepreneurs are born with the intuition (or sixth sense) to be entrepreneurs. Without this inborn intuition, an entrepreneur would lack what it takes to be successful. The great person school has similar characteristics as the great man leadership theory in that they have the instinct and insight to be successful.

This type of successful entrepreneur has several dominant characteristics: independence, persistence and self-esteem. This individual has exceptional faith in their ability to achieve and is able to inspire and motivate. Significant change in their personality is almost impossible due to the strength and clarity of these beliefs [12].

3.5 Classical school

The classical school ascribes to the concept that entrepreneurs are distinctively innovative and creative. Unlike the traits leadership theory where leaders' personal traits are taken into account, the classical school focuses on strictly creativity and innovation.

The underlying premise of this school is that entrepreneurship can be learned and developed. The entrepreneur must seek and manage opportunity and foster innovation. Failure of an entrepreneurial endeavor is the product of poor management strategies [13].

3.6 Leadership school

The leadership school takes into consideration that entrepreneurs can adapt their styles to fit the needs of their customers. Unlike transformational leadership theory where leaders influence and empower their followers, entrepreneurs may be willing to adapt their styles but they cannot influence others since they do not have followers.

A pervasive concept of this school is that an entrepreneur is responsive to the needs of individuals and achieves assigned goals. This school also ascribes to the belief that entrepreneurs must also be successful mentors. They must develop their protégé, giving them the critical skills necessary for success [14].

4. Five common traits

Leaders and entrepreneurs share common values and traits. The literature identified five traits common in individual(s) that are found as both a leader and an entrepreneur.

4.1 Risk acceptance and risk management

It is generally accepted that risk is an accepted component for both leaders and entrepreneurs. Entrepreneurs create new ventures and one of the "most distinctive" features of this type of behavior is risk taking [15]. Risk averse decision makers generally choose activities that result in lower risk at the expense of greater rewards. Those willing to accept greater risk do so with the expectation of achieving greater rewards [16]. Analyzing risk incorporates judgment, logic, intelligence and methodical deliberation [17].

Risk management is a process initiated by identifying the risks associated with an activity. The risks are then evaluated and prioritized. The purpose of the process is to minimize and limit

the impact of adverse occurrences [18]. Risk management in an entrepreneurial organization is especially critical due to the inherent insecurity and uncertainty of the venture [19]. Complex problems are more likely to have high levels of turmoil and confusion resulting in a greater need to be innovative and creative. Proper risk management procedures then become even more compelling [20].

4.2 Trust

Trust is defined as the "assured reliance on the character, ability, strength, or truth of someone or something; one in which confidence is placed".[1] A critical factor in determining whether a leader or an entrepreneur is successful is the extent in which trust is achieved [21]. One of the components of trust is that the individual desiring to be trusted must also have the ability, skill, capacity and competence to accomplish the desired result [22]. Trust is enhanced and strengthened through discussion (consultation) effective communication and common beliefs and ideals [23].

It has been suggested that there are three factors affecting levels of trust: the probability that actions will be in the best interests of all, that there is a degree of vulnerability for those relying on trust, and that trust involves a degree of reliance by following, and conforming to the directions of another [24]. Trust is also a process. It is fluid and not constant. It has been alluded to that there are three segments: developing and building trust where it is created and enhanced; stability where trust ultimately exists; and finally, termination where it is no longer needed or has deteriorated [25].

4.3 Vision

From the perspective of the entrepreneur and the leader, vision has common traits. Vision is the ability to conceptualize an idea. It must be credible and achievable. Factors for success must be identified and necessary resources must be recognized and located. These factors could be technology, financial, human capital and/or the ability to manage [26]. Vision is also the ability to internalize ideals and principles and align them with objectives. Individuals would then be motivated to achieve the vision [27].

Entrepreneurs and leaders must be able to transform the vision and appeal to people so that they perceive the vision to be realistic and attainable [28]. Efforts to exploit opportunities and influence individuals or groups of individuals are common to both the leader and the entrepreneur [29]. Entrepreneurs not only see opportunities (understand the ways and means), but are able to marshal resources to carry out their vision [30]. The vision must create an image in the minds of the followers that the followers belong to something bigger and more important [31].

4.4 Decision Making

There are many factors involved in the decision making process. The primary consideration is the quality of the decision. It must be logical, informed, and consistent with the desired outcome based on the existing information [32]. Decision success is predicated on properly articulating the problem that needs to be solved and allowing ample time for the decision to be implemented. Additionally, allowing active rather than passive participation by members raises success rates to over 80 percent [33].

After properly articulating the problem, delegating authority to an individual is a logical step. Given authority, the individual becomes committed to solving the problem and the necessary changes can take place. This expedites change rather than forcing it, ensuring compliance with the directive [33]. When the decision making process is based on biases and heuristics, it is fundamentally impossible to evaluate risk. The resulting uncertainty and ambiguousness becomes overwhelming and complicates the process to such a degree that all decisions become suspect and questionable [33].

[1] http://www.merriam-webster.com/dictionary/trust

4.5 Empowerment

Empowerment is the process of sharing power with subordinates. In this process, leaders grant authority to individuals that allow them to have both input and control over situations, resources or circumstances with which they are involved [26]. Included in this process is increasing the discretion individuals have in deciding what actions to take. This then creates a greater degree of ownership and commitment [27]. It has been suggested that "empowerment may be nothing more than a recycled version of Theory Y and people-oriented leadership" and a component of modern management practices [28].

Empowerment is also multifaceted and includes several necessary traits, among them initiative, responsibility, knowledge and creativity [29]. Empowerment allows an individual to not only be part of the identification process of defining the problem, it also allows the individual to generate solutions that are original, practical, and encourage creativity [30]. It stands to reason, that when an individual perceives they are empowered and are performing meaningful tasks, there is greater motivation to perform at superior levels [31]. Empowered individuals will generally take more risk, becoming more vulnerable. A positive consequence and additional benefit of this risk and vulnerability is that these individuals have greater trust in their leaders [32].

5. Relationship between leaders and entrepreneurs

Effective leadership understands *risk acceptance* is directly measured through outcomes and rewards - the greater the risk the greater the rewards. The opposite is also true of those leaders who choose to take less risk reap smaller rewards. Risk acceptance is a common trait found in both leaders and entrepreneurs with the ultimate goal building a successful and profitable business.

Effective leadership understands *trust* is a process built on relationships where they share common beliefs and goals for the organization. While entrepreneurs understand trust depends upon relationships with others, entrepreneurs may not have an instant network in the form of a board of directors or a senior management team. Their relationships with customers and vendors' goals as leaders do.

Effective leadership identifies *vision* as the ability to conceptualize an idea and transform this idea into an image in the minds of their followers. While leaders and entrepreneurs have this trait in common, leaders have the resources and the network to transform ideas into end products that entrepreneurs may not have.

Effective leadership recognizes *decision making* as a process where quality is a prominent factor. Decisions that demonstrate quality start with the desired outcome in mind whose components are logical, informed and consistent. Entrepreneurs understand the decision making process as well but may lack one or more of the components to ensure quality decisions.

Effective leadership sees *empowerment* as the process of sharing authority, input and control over situations, resources or circumstances in which they are involved [26]. Leaders want to lead others or influence them to be successful and share in the rewards of the organization. Entrepreneurs often act alone. In fact, entrepreneurs often feel threatened by sharing their authority or control over their businesses.

6. Conclusions

By definition, leaders must have followers or they cannot be leaders. Entrepreneurs however, while needing participants, can be successful without requiring followers. When there are commonly accepted traits among different groups it is many times assumed that these traits are shared and employed in the same manner. However, it must be clearly noted that this is not true between leaders and entrepreneurs. While the traits are the same, the audience sought by leaders and entrepreneurs and the application of the traits to the audience they seek is different.

This study has identified and analyzed common traits shared by both leaders and entrepreneurs. It has also shown that there are subtle but obvious nuances that separate these traits. These distinctions must be clearly known and accepted by individuals that are, or will become, both leaders and entrepreneurs. While knowledge and acceptance alone does not ensure an effective partnership, failure to understand these subtleties and distinctions will make a successful alliance of the traits between a leader and an entrepreneur difficult if not impossible to achieve.

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Lindy's Chicken Live Case Study

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Abstract

The purpose of this paper is to gain insight into the business processes of a local chicken shop. Ultimately, our research will allow us to use a computer program to simulate the supply chain process for Lindy's Chicken, taking into consideration the products that must be sold before expiration.

1. Introduction

Lindy's Chicken is one of Tallahassee's novel diner shops. They live by the motto, "Since 1968", so they must be doing something right! This live case study examines Lindy's Chicken, a local chicken joint that handles various lunch needs in Tallahassee, FL. Using the ProModel Simulation software (Harrell, et. al. 2004), the study determines customer frequencies, arrival times, and other variables to create a simulation of the company processes.

2. Company Overview

Lindy's Chicken was founded in 1968 by Ray Salis, in Tallahassee, FL, with a simple lunch counter serving fried chicken and soon turned into a Tallahassee franchise. Currently owned by Salis' son Ray Salis Jr., the strong family tradition of serving great "You're Going to Love It" chicken continues. Lindy's has been serving amazing chicken in a variety of ways for nearly 50 years. Today Lindy's has seven locations in Crawfordville, Tallahassee, and Blountstown. The locations are open seven days a week from 10:00 am to 9:00 pm. This wide range of hours provides each customer an ample amount of time to make it to the restaurant. Many view Lindy's as the go to spot to pick up lunch. Their peak hours are Monday through Wednesday from 11:30am-2:00pm and all day Thursday and Friday. Within the Tallahassee area, Lindy's Chicken is renowned for their double marinated chicken sandwich, custom gizzards and hot wings. Ray Salis views their competitors as the major fast food chicken chains: Chick Fil' A, Guthries, Chubby's Chicken, Zaxby's, KFC, and Popeye's.

3. Customer Observations

During our initial observation, on a Wednesday between the times of 3:50pm and 4:50pm there was a total of 34 individuals who purchased something from the restaurant (Tables 1.1 and 1.2). Out of the 34 customers, 65% of the customers were black, 32% were white, and 3% of the customers were placed in the 'other' category (Figures 1.1 and 1.2). Also, within the 34 customer's, 53% of the customers were in

between the ages 21 and 45, 20% were in the age range between 13 and 20, 15% were 46 and up, and 12% of the customers were 12 and under.

4. Distribution Channel

Currently, Cagles Chicken is one of the top poultry producers in the world selling more than 400 million pounds of chicken to supermarkets, food distributors, food-processing companies, fast-food chains, restaurants, and schools since its founding (Figure 2). As one of the Lindy's suppliers, Cagles Chicken is delivered to the seven Lindy's facilities located within the Tallahassee, Blountstown, and Crawfordville area. This is done by using refrigerated trucks that are capable of moving the various products which are bought wholesale. After that, Lindy's gourmet chefs prepare the poultry products to a delightful golden brown. Lindy's offers over 20 different varieties of chicken and gizzard goodness.

5. Goodness of fit test

The null hypothesis for Lindy's Chicken is that the times are exponentially distributed with the mean of 3.525 (Figure 3). The alternative hypothesis is that the times are not exponentially distributed with the mean of 3.525. The sample size used for the Goodness of fit test was 40 people, and the frequency distribution of the data with equiprobable cells based on the inferred distribution of Lindy's Chicken was five. The expected frequency of each cell is eight, which meets the minimum expectation of five, so no adjustment is needed (Table 2). The chi-square statistic for Lindy's Chicken comes to a total of 3.25. The number of degrees of freedom is three. The significance level is the probability of declining the null hypothesis when it is true. We will use a level of significance of .05 for Lindy's Chicken. The critical chi-square value from the chi-square table is 7.815. Therefore, we will fail to reject and conclude that the interruption times are exponentially distributed since 3.25 is less than 7.815 (Table 2).

6. ProModel Simulation

ProModel is a discrete event simulation software developed by ProModel, Inc. It is used for evaluating, planning or designing manufacturing, warehousing, logistics and other operational and strategic situations (Figure 4). After designing Lindy's Chicken restaurant layout in ProModel, we were able to derive Lindy's annual revenue by setting the average cost of the arriving customers to $9.89 allowing us to generate a profit and loss statement.

7. Profit & Loss Statement

According to our research Lindy's Chicken generates operating expenses totaling $171, 870.40 with salaries and wages amounting to $152,370.40 based on their employees receiving a minimum hourly wage rate of $8.05 (Table 3). From observing daily operations at Lindy's we learned that they always have four employees working. By applying the hourly rate and multiplying it by the four employees, we were then able to multiply the hourly rate by 91 (the amount of hours a week that a combination of two or more employees work so that no one worker works more than 40 hours) to get our weekly expense. The other expenses included in operating expense were utilities, supplies and insurance which totaled $19,500. Setting their average menu price at $9.89 and running the simulation Promodel generated annual sales of $657,747.12. After calculating a gross profit of $242,089.12 and total operating expenses of $171,870.40 we believe their net income to be $56,666.51.

8. Conclusion

Ray Salis Jr., has extended the Lindy's Chicken business to over 48 years. Lindy's Chicken has expanded to 7 locations. This does not necessarily limit maximization of procurement

and advertisement. To illustrate, Lindy's Chicken should consider improving efforts to advertise to younger generations. A review of customer demographics conveys that the primary age group of consumers that frequent its restaurants are between the ages of 21-45 with a large portion of these consumers being older than 35. Millennials are known to be a more health conscious generation. "*Data show that consumers relate the word fresh with healthy. Nine in 10 people think fresh foods are healthier, and 80% look for the descriptor ''fresh'' when it comes to retail. Healthy foods are also linked to the phrases house-made or home-made, as well as keywords such as from scratch, artisan, authentic, seasonal, real, and never frozen. Consumers also have renewed interest in animal welfare when it comes to their foods. Farm Raised, grass-fed, free-range, and cage-free are perceived as conveying healthfulness"* (Sloan, 2015). Taking this into consideration, we believe that revamping the sanitation standards could attract millennials not acclimated to the "mom and pop" food experience. Lindy's Chicken should also explore alternative food choices to appease the new health conscious generations through advertising methods such as Captiveyes, billboards, and social media. Captiveyes, a local Tallahassee company that builds networks of indoor digital billboards located in locations that cater to specific age groups, such as gyms, restaurants, clubs, bars, doctors' offices, salons, barber shops, and Universities (Figure 5). Through eye captivating entertainment that transitions continuously on a loop, Lindy's could use this opportunity to promote their fresh and homemade food.

Although the aforementioned may be true, Lindy's chicken has mastered an effective supply chain from its four source channels, customers spent an average of 15 minutes in the system (calculated by Promodel), and Lindy's Chickens net income is estimated at an impressive $56,666.51. This ultimately comes together to show for Lindy's Chicken, 40 years of service that have cultivated a loyal customer base has grown with the organization. Ultimately, our strategic recommendations for their efforts moving forward will allow the company to remain competitive for an additional 40 years.

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Appendix

Figure 1.1

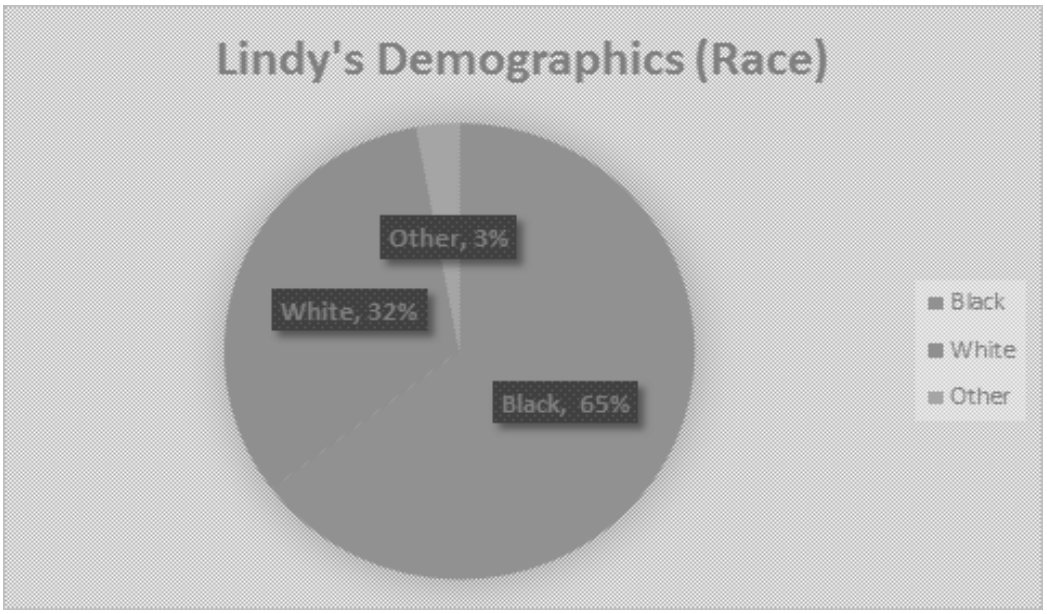


Figure 1.2

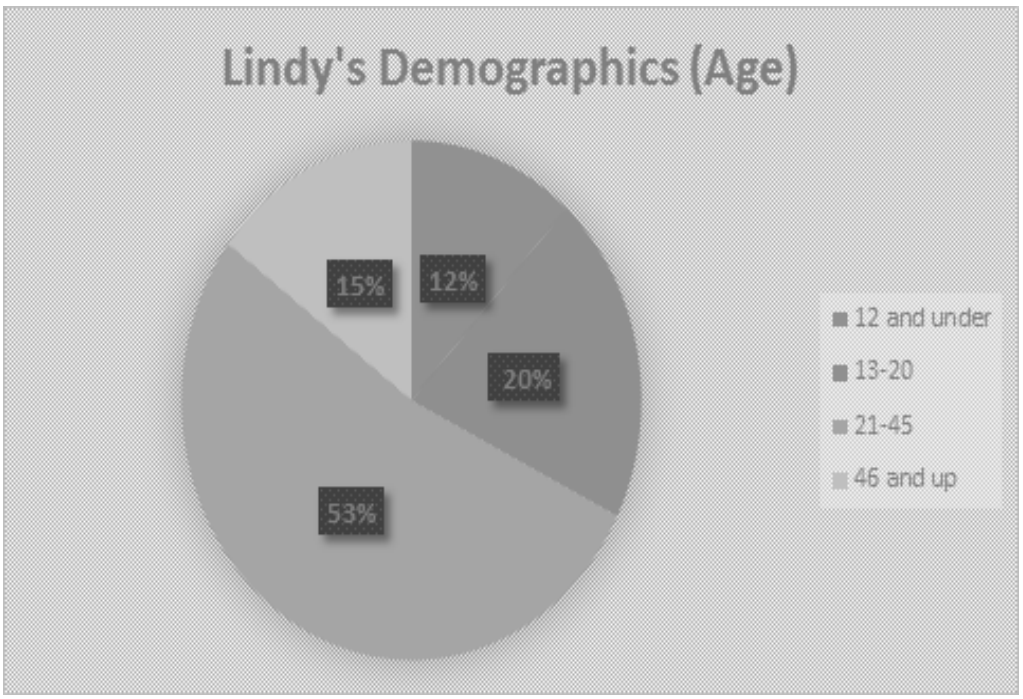


Figure 2.1Table 1.1

Lindy's Stimulation Logic						
Customer Number (1)	Arrival Time (2)	Interarrival Time	Begin Service Time (3)	Service Time (4)	Time in Queue (6)=(3)-(2)	Time In System (7)=(4)-(2)
			DAY 1			
1	3:50	0:02	3:54	4:00	0:04	0:10
2	3:52	0:01	3:58	4:00	0:06	0:08
3	3:53	0:04	3:56	3:58	0:03	0:05
4	3:57	0:03	4:00	4:14	0:03	0:17
5	4:00	0:01	4:12	4:34	0:12	0:34
6	4:01	0:01	4:05	4:09	0:04	0:08
7	4:02	0:13	4:12	4:50	0:10	0:48
8	4:15	0:00	4:20	4:22	0:05	0:07
9	4:15	0:06	4:22	4:24	0:07	0:09
10	4:21	0:23	4:32	4:52	0:11	0:31
11	4:44		4:50	5:00	0:06	0:16
			DAY 2			
12	3:52	0:08	3:52	4:07	0:00	0:15
13	4:00	0:07	4:00	4:10	0:00	0:10
14	4:07	0:09	4:07	4:12	0:00	0:05
15	4:16	0:04	4:16	4:25	0:00	0:09
16	4:20	0:10	4:20	4:32	0:00	0:12
17	4:30	0:00	4:32	4:52	0:02	0:22
18	4:30	0:00	4:32	4:52	0:02	0:22
19	4:30	0:00	4:32	4:52	0:02	0:22
20	4:30		4:32	4:52	0:02	0:22

Figure 2.2 Table 1.2

Lindy's Stimulation Logic						
Customer Number (1)	Arrival Time (2)	Interarrival Time	Begin Service Time (3)	Service Time (4)	Time in Queue (6)=(3)-(2)	Time In System (7)=(4)-(2)
			DAY 3			
21	3:45	0:00	3:45	3:49	0:00	0:04
22	3:45	0:00	3:48	3:55	0:03	0:10
23	3:45	0:00	3:49	3:55	0:04	0:10
24	3:45	0:04	3:51	3:55	0:06	0:10
25	3:49	0:01	3:50	4:00	0:01	0:11
26	3:50	0:01	3:59	4:07	0:09	0:17
27	3:51	0:02	3:53	4:10	0:02	0:19
28	3:53	0:09	3:57	4:11	0:04	0:18
29	4:02	0:02	4:02	4:13	0:00	0:11
30	4:04	0:01	4:04	4:12	0:00	0:08
31	4:05	0:01	4:15	4:22	0:10	0:17
32	4:06	0:01	4:15	4:30	0:09	0:24
33	4:07	0:02	4:15	4:30	0:08	0:23
34	4:09	0:09	4:18	4:27	0:09	0:18
35	4:18	0:02	4:19	4:28	0:01	0:10
36	4:20	0:04	4:20	4:22	0:00	0:02
37	4:24	0:00	4:25	4:30	0:01	0:06
38	4:24	0:04	4:24	4:32	0:00	0:08
39	4:28	0:06	4:32	4:42	0:04	0:14
40	4:34		4:34	4:47	0:00	0:13

Figure 3Figure 2

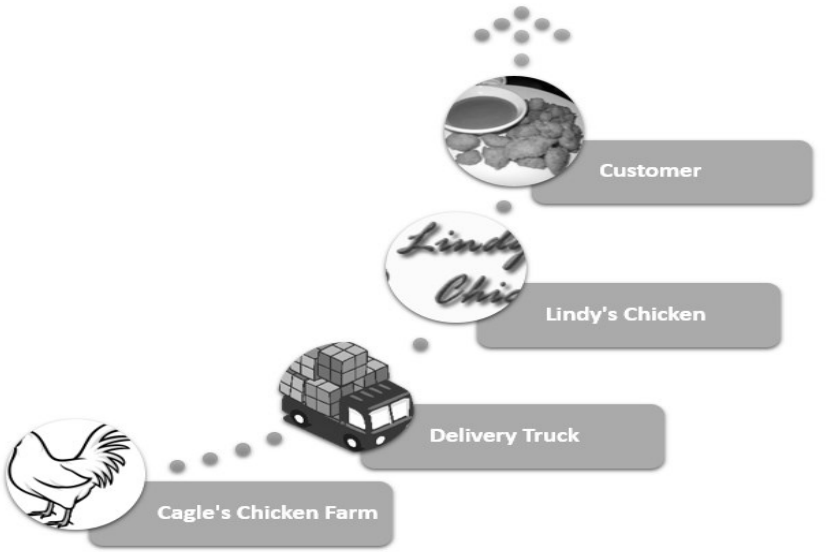


Figure 4Figure 3

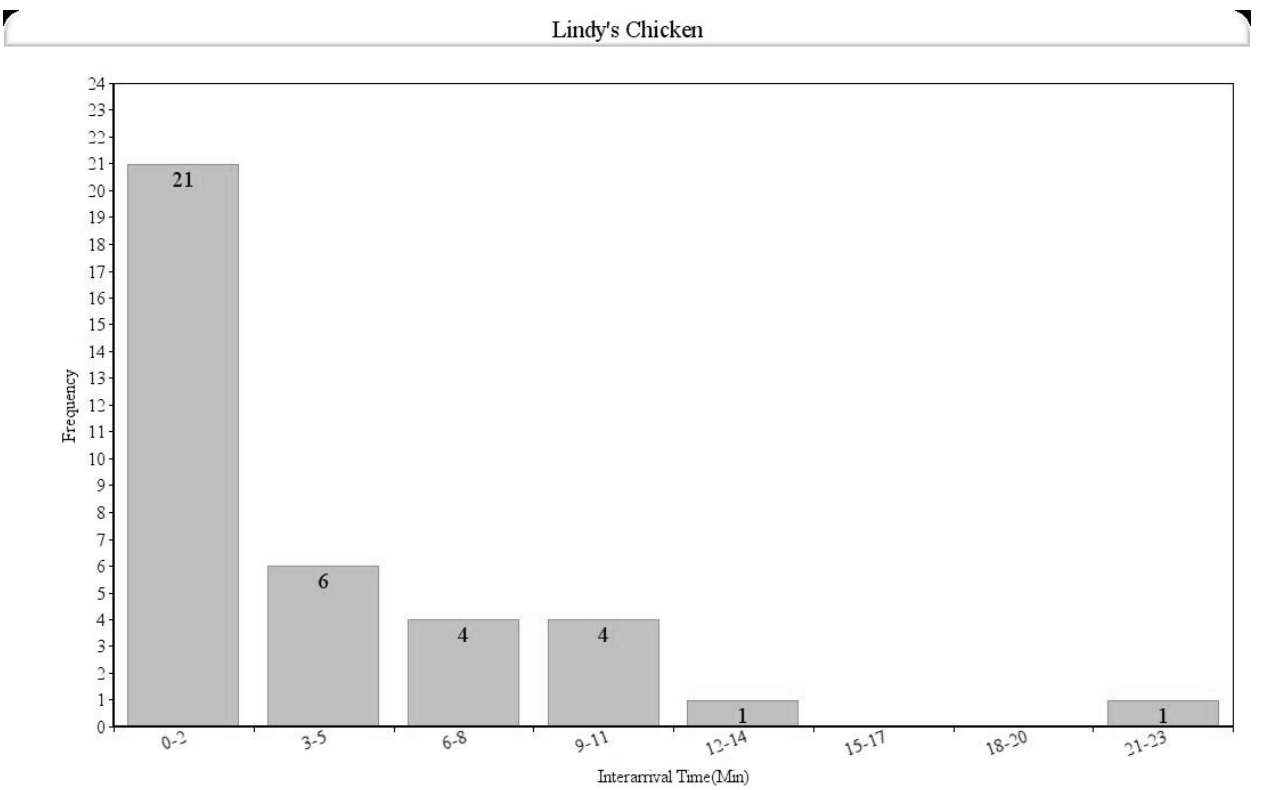


Figure 5 Table 2

Cell	Inter-arrival	Observed Frequency o_i	Ho Probability	Ho Expected Frequency	$(o_i-e_i)^2 / e_i$
1	0 - .79	11	.20	8	1.125
2	.79 -1.80	8	.20	8	0
3	1.80 - 3.23	6	.20	8	.5
4	3.23 - 5.67	5	.20	8	1.125
5	5.67-∞	10	.20	8	.5

Figure 6 Figure 4

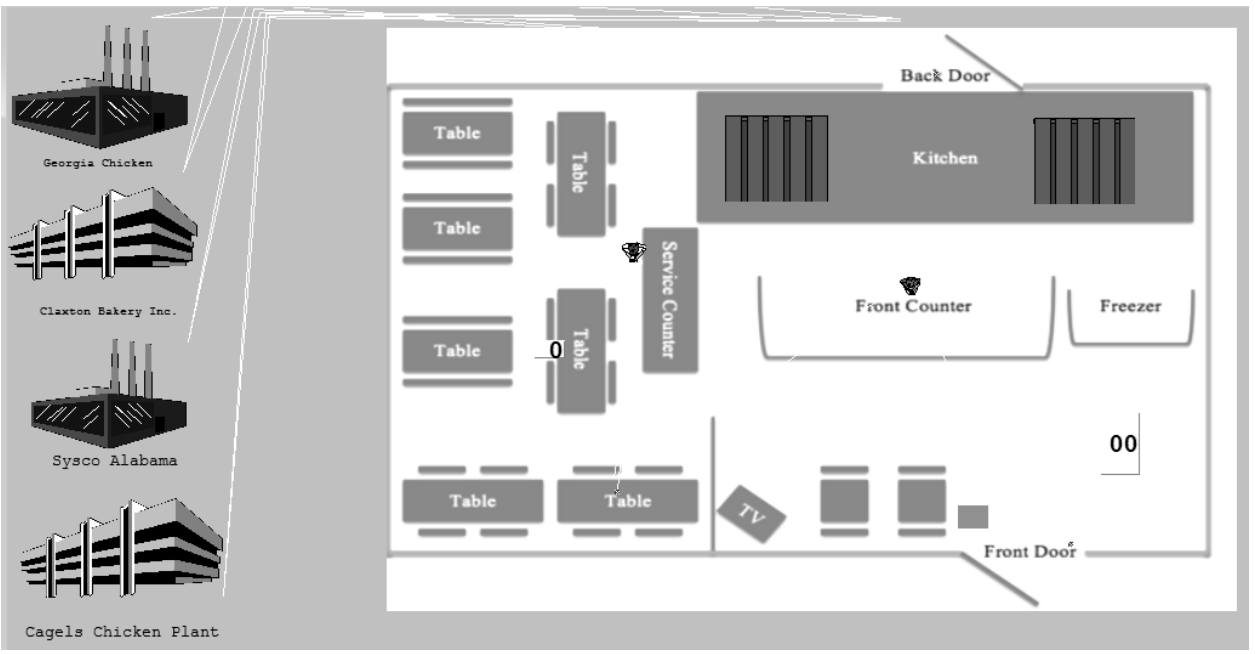
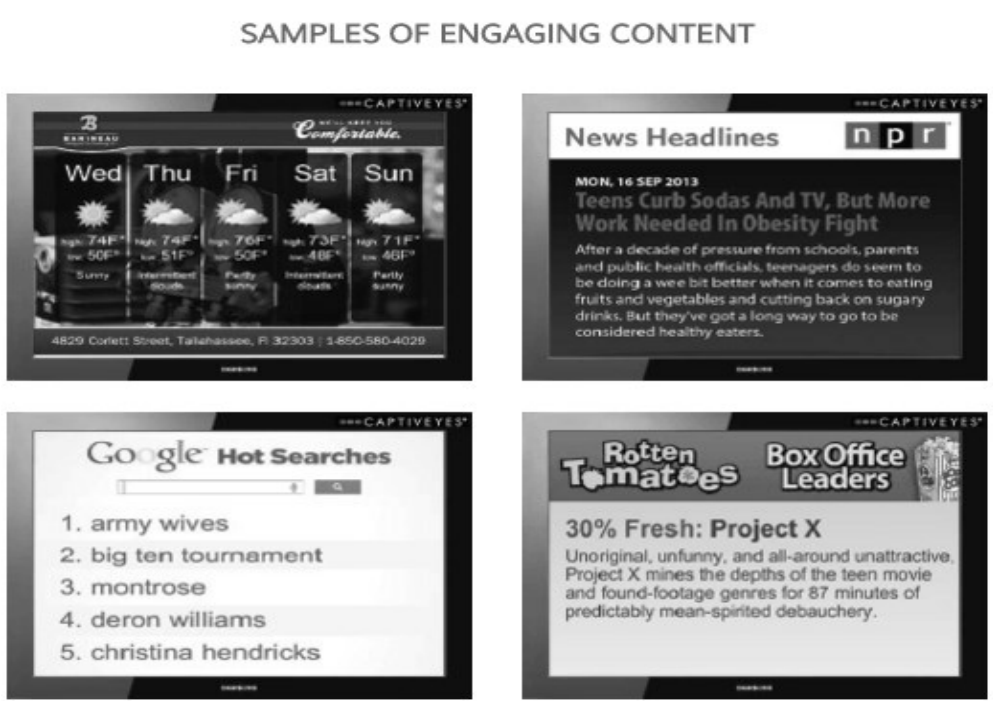


Figure 7 Table 3

Profit And Loss Statement	
Revenue	**Yearly**
Sales-Derived From Promodel Simulation	$ 657,764.12
Raw Materials Cost	$ 415,675.00
Gross Profit	$ 242,089.12
Operating Expense	
Salaries & Wages	$ 152,370.40
Utilities(Gas, Electricity,Water,Trash And Sewage)	$ 8,400.00
Supplies	$ 9,600.00
Insurance	$ 1,500.00
Total Operating Expenses	$ 171,870.40
Income before income Tax	$ 70,218.72
Income Tax Expense	$ 13,552.21
Net Income	$ 56,666.51

Figure 8 Figure 5



Merv's Melt Shop Live Case Study

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Abstract

This live case study examines "Merv's Melt Shop[3]," a restaurant in Tallahassee, Florida that is dedicated to providing great meals to the local community by using fresh high quality ingredients, locally baked bread, and their own brand of innovation. The study determines customer frequencies, interarrival times, service times and additional variables that allow for development of an accurate representative simulation using Pro Model software.

1. Introduction

The purpose of this paper is to gain insight into the business processes of Merv's Melt Shop while simulating their operations and recommending practical ways of improving the processes. This study analyses the service facility, customer frequencies, distribution of arrival time, distribution of service time and other variables required to successfully simulate the company's processes. A computer model is then built to simulate the operations using Pro Model software.

2. Background of the Company

Merv's Melt Shop is a local restaurant in Tallahassee, FL that is dedicated to providing great meals to the local community by using fresh high quality ingredients, locally baked bread, and their own brand of innovation. It was founded in April, 2014. It is owned by three people Dave Raney, Omar Hajjar and Brad Buckenheimer. There are nine employees consisting of six kitchen staff and three administrative staff.

Open Hours: 7 days a week from 8:00 am – 3:00 pm
Peak Hours: 9:45 am – 10:30 & 11:00 am – 1:30 pm
Address: 825, Railroad Avenue, Tallahassee, FL 32310
Website: www.mervsonline.com

Market

- Competitors
    1. All Saints
    2. Kubano
    3. Crepe Vine
    4. Bread & Roses
- Merv's competes through differentiation strategy by offering the following:
    - Quality
    - Quick delivery
    - Freshness

Products

Menu options include the following categories:

- Breakfast Melts
- Sandwiches
- Burgers
- Fresh Salads
- Soups
- Snacks & Sides
- Chips

There is also option to make your own melt

Suppliers

Raw materials for the product are Texas toast, eggs, cheese, powdered sugar and sausage. They are supplied by two suppliers: CBI (Cheney Brothers Inc.) and FL Food Services.
Cheney Brothers Incorporated is based in Ocala, FL while FL Food Services is based in Gainesville; FL. Orders are placed manually by email on Monday, Wednesday, Friday and Saturday. The five most frequently ordered items are bacon, sausage, Texas toast, eggs & American cheese. Inventory is received the day after the order is placed. For this live case we have chosen to focus on the "Frenchie Sandwich". See Table 1 for recipe.

3. Customer Observation

Customers were observed for an hour and thirty minutes on a visit to Merv's Melt Shop. We were able to determine the interarrival time and the service time. The data for the 30 customers that were observed are shown in Table 2. The interarrival time has a mean of 2 minutes and 36 seconds and a standard deviation of 2 minutes 30 seconds. The time in service has a mean of 9 minutes and 10 seconds and a standard deviation of 4 minutes and 36 seconds. Frequency distribution tables and histograms were plotted for both interarrival time and time in service as shown in Tables 3 and 4, and Figures 1 and 2.

The initial observation was made during Merv's peak period. In other to have more accurate representation, another visit was made to observe Merv's customers during the off peak period. The comparison of peak and off peak period is shown in Table 5.

4. Customer Data Classification

A frequency table was generated for the observed interarrival times and histogram was plotted. The interarrival times seem exponentially distributed so the chi-square goodness of fit test was used to test the hypothesis.

Chi-Square Goodness of Fit Test for Interarrival Times

Step 1: Data analysis and inference of underlying distribution
Sample size "n" = 30
Estimated mean = 2.60
Standard deviation = 2.50
From the histogram for the distribution and the closeness of the estimated mean value (2.60) to standard deviation (2.50), the data appear to be evenly distributed.
H_o (Null Hypothesis): Interarrival times are exponentially distributed around the mean
H_a (Alternate Hypothesis): Interarrival times are not exponentially distributed around the mean

Step 2: Frequency distribution
Intervals, $k = (2n)^{1/3}$

$$k = (60)^{1/3}$$
$$k = 4$$

Calculated intervals using probability density function

$$f(x) = \frac{1}{\beta} e^{-(x-\mu)/\beta} \qquad x \geq \mu; \beta > 0$$
$$x = -\beta \, In \, (1 - \mu)$$

Where β = mean
μ = uniformly distributed

$$f(0) = -2.6 \, In \, (1 - 0) = 0$$
$$f(1) = -2.6 \, In \, (1 - 0.25) = 0.75$$
$$f(2) = -2.6 \, In \, (1 - 0.50) = 1.80$$
$$f(3) = -2.6 \, In \, (1 - 0.75) = 3.60$$
$$f(4) = -2.6 \, In \, (1 - 1.0) = \infty$$

Step 3: Expected frequency for each cell
Expected frequency (e) for each cell (i) equals np_i.

$$e_i = np_i$$
$$e_i = 30\ X\ 0.25 = 7.5$$

Step 4: Calculate the chi-square characteristics
Chi-square test statistic

$$x^2{}_{calc} = \sum_{i=1}^{4} \frac{(Observed - Expected)^2}{Expected}$$
$$x^2{}_{calc} = 0.03 + 0.30 + 0.30 + 1.63$$
$$x^2{}_{calc} = 2.26$$

Step 5: The number of degrees of freedom

$$Number\ of\ degrees\ of\ freedom = k - s - 1$$

Where k = number of cells

s = number of parameters estimated from the data for defining the distribution (in this situation s is one because only one parameter, the mean is estimated from the data.

So number of degrees of freedom 'k' = 2. See Table 6 for summary of the chi-square test.

Step 6: Desired level of significance (α)
This is the probability of rejecting a null hypothesis (H_o) when it is true. Typical level of 0.05 is used.

Step 7: Critical chi-square value from the chi-square table
$x^2_{k-s-1,\propto} = x^2_{2,0.05}$ = 5.99
Step 8: Decision

$$x^2_{Calc}\ (2.26) < x^2_{2,0.05}\ (5.99)$$

Since $x^2_{Calc}\ (2.26)$ is less than$x^2_{2,0.05}\ (5.99)$, we fail to reject Ho (null hypothesis). This means we can assume an exponential distribution is a good fit for the observed interarrival times.

5. Simulation

Merv's operations and business processes that were observed were reproduced using ProModel[2][4] simulation software This was done by using the shop's layout to illustrate locations such as the entrance, queue, cashiers, dining area and kitchen on ProModel. Input data were the estimated mean of interarrival time and service time, and the capacity of the dining area since customers had to wait in dining area to receive their meals.

We also simulated the delivery of raw materials by the company's two suppliers CBI (Cheney Brothers Inc.) and FFL (Florida Food Services) based on actual delivery rates. Deliveries are made four times in a week. This information was used to replicate the shop's operations.

Also, the price of the Frenchie sandwich $7.95 which is the highest selling product and the focus of our study, along with the average cost of a drink at Merv's $2.13 making a total of $10 was used as the average cost of an order. This information was useful in simulating revenue and in generating the profit and loss statement. The simulation period was 210 hours which is the total number of operating hours per month at Merv's (7 hours every day of the month).

Simulation was run for both the peak and off peak period.

6. Forecast

In order to accurately forecast demand, historical GDP (Gross Domestic Product) data were put into "FOURCAST[1]", a time series analysis and forecasting computer program. FOURCAST generated the trend shown in Figure 4. This was then used to forecast interarrival times and expected number of customers as shown in Table 7. Figure 5 has the forecast for Merv's net income for the next four quarters.

7. Result

From the result at the end of the simulation period we observed the number of customer orders that were processed within the period, the cost of the orders and the revenue. This was done for both peak period and off peak period; see Table 8 for results for both periods. The weighted average of both periods, was then used to generate the Income Statement (Profit & Loss) shown in Table 9.

Also, ProModel generated histogram for time spent in queue at Merv's Melt Shop (shown in Figure 6) and capacity utilization charts for resources at Merv's Shop. These are shown in (Figures 7a and 7b). The following observations were made from the results displayed at the end of the simulation:

- There is spare capacity at the cashier because the queue is empty 87.11% of the time. This means that Merv's can afford to have just one cashier take orders instead of two.
- Customers spend an average of 25mins in the system (from time of arrival until the time order is received) and about 95% of the time is spent waiting for food to arrive.
- Based on forecast trend, interarrival time is expected to reduce significantly in the next couple of months which means there would be more customers.

8. Recommendation

The following recommendations are based on our observation of Merv's Melt Shop and the result of the simulation we performed using ProModel.

- Reduce time spent in system by increasing capacity. From the simulation we noticed customers spend an average of 25 minutes in the system from when they arrive to when they received their order. As a result of the long wait for orders to be processed the dining area is occupied 99% of the time. Also, some customers have taken to social media to complain about the waiting time. Freshness is one of Merv's strategies for competing but if service takes long this may deter customers from coming. Orders need to be processed faster by increasing manpower or reviewing their processes.
- Have one person take order and the other person process orders at peak time. The queue is empty 80% of the time so Merv's can afford to have the second cashier join the kitchen staff to prepare meals rather than having an idle resource or underutilized capacity.
- Improve process to enable faster food processing time
- Increase sitting area capacity to accommodate more customers per time.
- Implement application software that would enable customers to place orders prior to arrival.

9. References

[1] FOURCAST: Application program, EMC, Inc., Version 2016.1, fourcast.net/fourcast, File: Fourcast.zip. (2016).
[2] Harrell,C., Ghosh, B. & Bowden, R. 2ed. Simulation Using ProModel. New York: McGrawHill. (2011).
[3] Merv's Melt Shop 2016. http://mervsonline.com/ (accessed March 18, 2016)
[4] PROMODEL: Simulation Software, ProModel Student Version: 8.6.0.963. ProModel Corporation, 2011.

Appendix

Table 1. Recipe for the Frenchie Sandwich

THE FRENCHIE SANDWICH		
SN	**Item**	**Per Serving**
1	French Toast bread	2 slices
2	Scrambled eggs	1 egg
3	Sausage patty	2 pieces
4	Bacon	3 strips
5	American cheese	2 slices
6	Syrup dipper	1 pack

Table 2. Observed Customer Data

Person (i)	Arrival to Merv's	Cashier /Begin Service	Food Received	Leave /Exit	Interarrival Time (Mins)	Time in Service (Mins)
1	11:27	11:28	11:35	11:52	0	7
2	11:35	11:37	11:41	12:02	8	4
3	11:35	11:38	11:46	12:02	0	8
4	11:36	11:40	11:50	11:58	1	10
5	11:40	11:41	11:42	11:42	4	1
6	11:44	11:45	11:51	11:51	4	6
7	11:51	11:52	11:56	12:03	7	4
8	11:52	11:52	11:58	12:04	1	6
9	11:52	11:57	11:59	13:03	0	2
10	11:57	11:59	12:06	12:19	5	7
11	11:57	11:59	12:06	12:19	0	7
12	11:59	12:00	12:11	13:04	2	11
13	12:00	12:01	12:06	12:39	1	5
14	12:04	12:05	12:15	13:04	4	10
15	12:09	12:11	12:23	12:40	5	12
16	12:09	12:11	12:23	12:40	0	12
17	12:14	12:18	12:23	12:23	5	5
18	12:23	12:25	12:32	13:02	9	7
19	12:23	12:25	12:32	13:02	0	7
20	12:25	12:26	12:36	13:10	2	10
21	12:26	12:29	12:44	13:11	1	15
22	12:27	12:29	12:44	13:11	1	15
23	12:27	12:32	12:49	13:12	0	17
24	12:31	12:33	12:49	13:12	4	16
25	12:35	12:36	12:54	13:30	4	18
26	12:37	12:40	12:56	13:34	2	16
27	12:38	12:41	12:50	13:21	1	9
28	12:40	12:43	12:55	13:15	2	12
29	12:43	12:44	12:48	12:48	3	4
30	12:45	12:47	12:59	13:14	2	12
Average					2.60	9.17

Table 3. Interarrival Time

Frequency Table for Interarrival Time	
Interarrival Time (min)	Frequency
0-2	18
3-5	9
6-8	2
9-11	1
	30

Table 4. Service Time

Frequency Table for Service Time	
Service Time (Min)	Frequency
1.0-4.5	5
4.5-9.0	11
9.0-13.5	8
13.5-18.0	6
	30

Table 5. Peak Versus Off Peak Period

	Peak	Off Peak
Number of minutes	195	225
Percentage of total period	46%	54%
Interarrival time	2.6	5.21

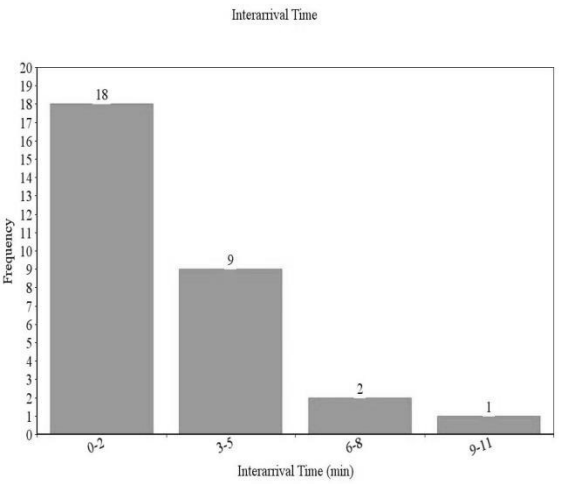

Figure 1. Histogram for Interarrival Time

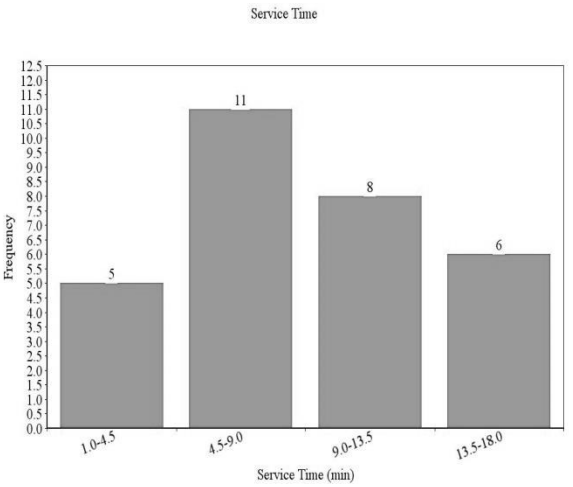

Figure 2. Histogram for Service Time

Table 6. Chi-Square Table

Cell (i)	*Interval*	*Observed Frequency* (o_i)	*Ho Probability* (p_i)	*Ho Expected Frequency* (e_i)	$\frac{(o_i - e_i)^2}{e_i}$
1	0.00-0.75	7	0.25	7.5	0.03
2	0.75-1.80	6	0.25	7.5	0.3
3	1.80-3.60	6	0.25	7.5	0.3
4	3.60-∞	11	0.25	7.5	1.63

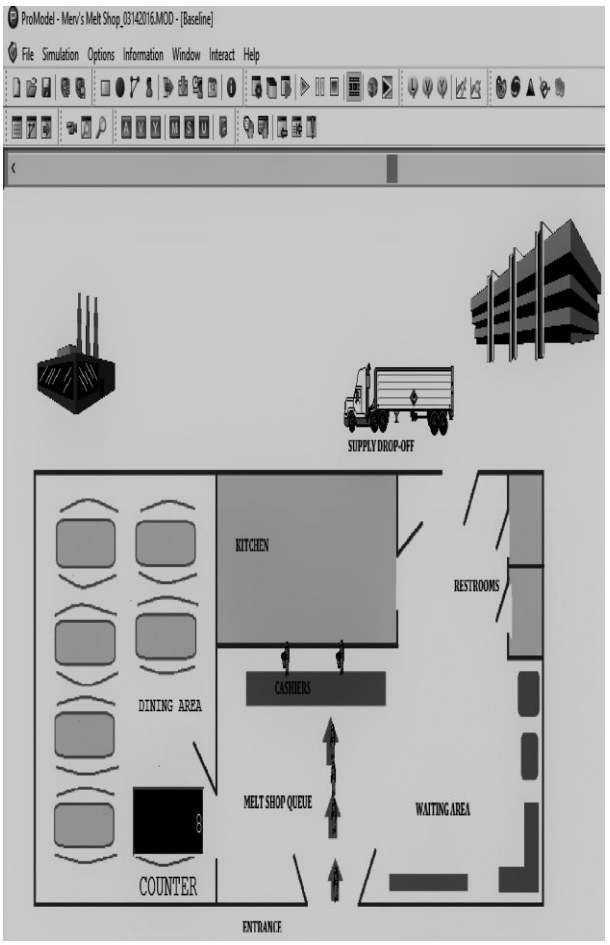

Figure 3. ProModel Simulation Screen Shot

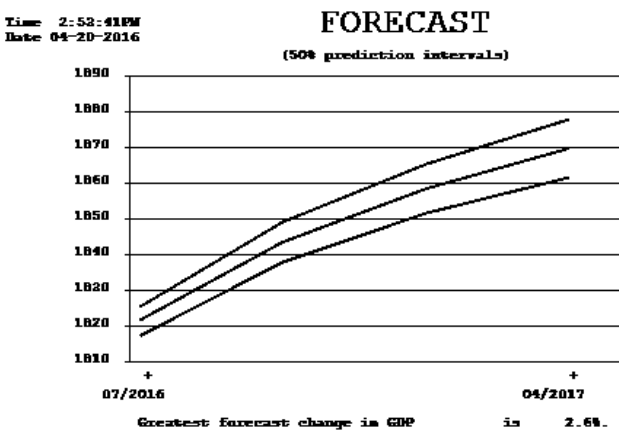

Figure 4. GDP Forecast

PERIOD	EXPECTED NET INCOME
Q1 2016	$ 3,673.08
Q2 2016	$ 3,774.24
Q3 2016	$ 3,825.73
Q4 2016	$ 4,035.83
Q1 2017	$ 4,181.48
Q2 2017	$ 4,293.25

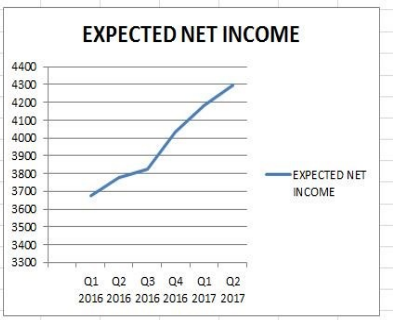

Figure 5. Merv's Net Income Forecast

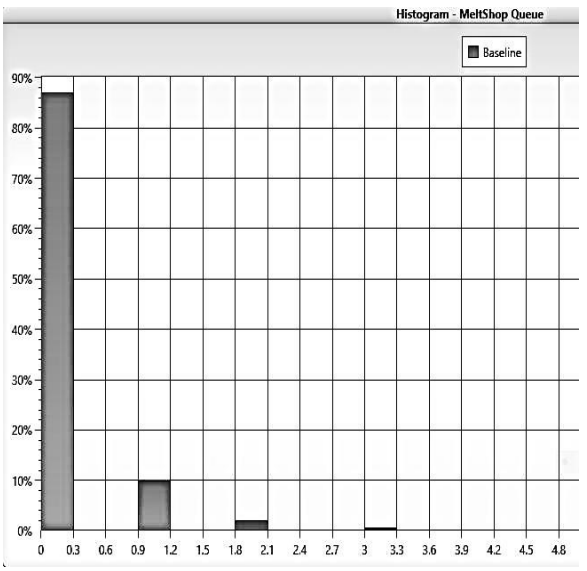

Figure 6. Time in Queue Histogram

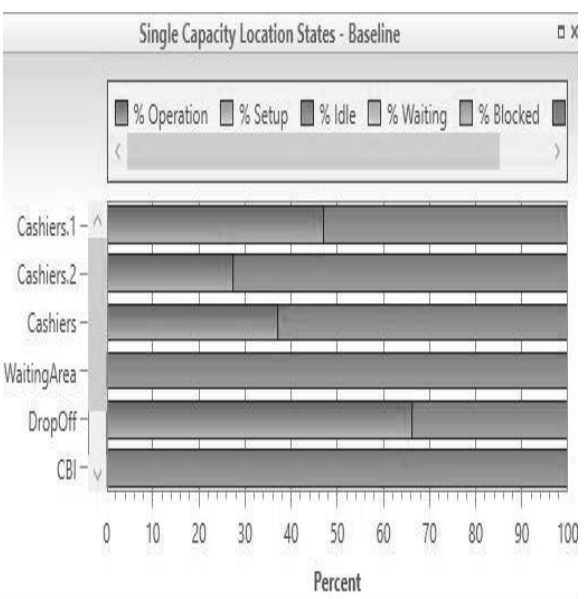

Figure 7a. Capacity Utilization at Merv's Melt Shop

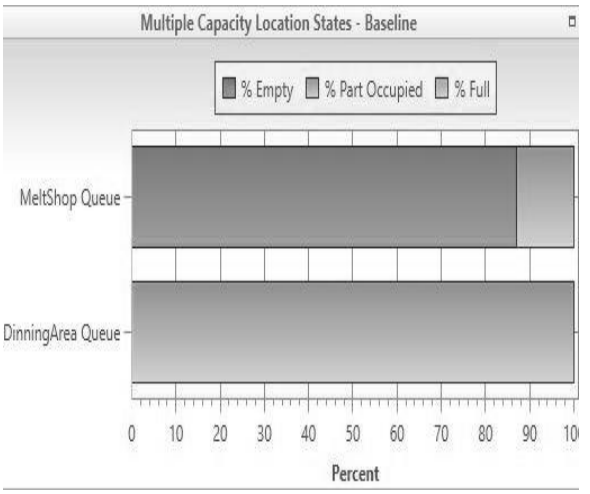

Figure 7b. Capacity Utilization at Merv's Melt Shop

Sales Returns/Discounts (Reduction)	$ -
Net Sales	$36,178
Cost of Goods Sold	$14,471
Gross Profit	$21,707
Operation Expenses	
Salaries & Wages	$15,593
Mortgage	$750
Utilities (Gas, electricity, water, trash and sewage)	$500
Insurance	$250
Total Operation Expenses	$17,093
Income before income taxes	$4,613
Income Tax Expense	$891
Net Income	$3,724

Table 7. Merv's Customers Forecast

SUMMARY OF FORECAST FROM FOURCAST			INTERARRIVAL TIME (MINS)		MONTHLY CUSTOMERS		
DATE	ACTUAL	Growth	Peak	Off Peak	Peak	Off Peak	Weighed Total
01/15/16	1,806		2.60	5.21	4,795	2,420	3,513
04/15/16	1,816	0.006	2.58	5.18	4,823	2,434	3,533
07/16/16	1,822	0.003	2.58	5.16	4,837	2,441	3,543
10/16/16	1,844	0.012	2.55	5.10	4,895	2,470	3,585
01/16/17	1,859	0.008	2.53	5.06	4,935	2,490	3,615
04/18/17	1,870	0.006	2.51	5.03	4,965	2,506	3,637

Table 8. Peak Versus off Peak Period Revenue

Revenue	Peak	Off Peak	
Sales	$49,245	$24,853	
Sales Returns/Discounts (Reduction)	$0	$0	
Net Sales	$49,245	$24,853	
Cost of Goods Sold	$19,698	$9,941	
Gross Profit	$29,547	$14,912	
Where peak period is 46%, and off peak period is 54% of total			
Revenue	**Peak**	**Off Peak**	**Total**
Sales	$22,864	$13,314	$36,178
Sales Returns/Discounts (Reduction)	$0	$0	$0
Net Sales	$22,864	$13,314	$36,178
Cost of Goods Sold	$9,145	$5,326	$14,471
Gross Profit	$13,718	$7,989	$21,707

Table 9. Profit & Loss Statement

PROFIT & LOSS STATEMENT	
Revenue	**Monthly**
Sales	$36,178

The Olean's Restaurant Live Case Study

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Abstract

This live case study examines The Olean's restaurant. The Olean's Restaurant is located in Tallahassee, Florida and is regarded as one of the best Soul Food restaurants in the city of Tallahassee. In the study, researchers observe the supply chain management of The Olean's Restaurant to gain a further understanding of the legwork it takes to run a business (food industry) as an entrepreneur. The researchers conducted several interviews with the owner of the restaurant to gain an understanding of the steps one must take to not only start a business, but to also sustain one. The researchers used ProModel, a manufacturing, and service simulator to recreate the supply chain management of the restaurant. While recreating the supply chain the researchers found several areas where the restaurant could improve their service times and distribution chain.

1. About the Olean's Restaurant

1605 S Adams St, Tallahassee, FL 32301
Hours of Operation:

- Monday – 0700-1530
- Tuesday – 0700-1530
- Wednesday- 0700-1530
- Thursday- 0700-1530
- Friday- 0700-1530
- Saturday- 0700-1200
- Sunday- Closed

Peak Times: 0900-1230

2. Competitors

- Earley's Kitchen
- Cassandra's Southern Café
- Harry's Seafood Bar & Grille
- Soul Vegetarian Restaurant & Catering
- Cypress Restaurant

Olean's Café was first established in 1996 and immediately won over the hearts and minds of residents in the surrounding community. It is hailed as a local gem for its good old-fashioned home cooking. In the 20 years since its inception, Olean's has hosted many political figures such as President Barack Obama, Governor Charlie Crist and Governor Rick Scott. Due in no small part to the loyal customer base it has built over the years The Olean's restaurant has weathered the storm of the financial crisis. These loyal customers rave enthusiastically about the quality of the soul food as well as the warm customer friendly service.

Food is an international language. Its preparation is heavily influenced by the culture of the region and can have various meanings associated with it. Throughout the Southeastern region of the United States, the term soul food is ubiquitous with gatherings of family and

fellowship. This type of comfort food is passed from generation to generation connecting family and friend's alike. This idea was expressed in the international journal of psycho-analysis. By attaching fond memories to this form of cookery, it allows the recipient to have an emotional reaction when eating the food (Pally, R, 1997). This link between food memory and experiential emotions has been used as the basis of major marketing campaigns for multinational organizations such as Kentucky Fried Chicken and Paula Dean's Home Cooking. Market leadership from these major organizations has allowed southern food to become an internationally recognized food genre.

According to IBISWorld Industry Market Research, single location full-service restaurants within the United States earned $175.4 billion in total revenue during 2014. This means that food consumption outside of the home is still a major industry. Olean's once held an advantage in the Tallahassee area as the only restaurant focused on southern home cooking. However, in recent years, new entrants have come in direct competition with Olean's Café.

One such example is Earley's Kitchen, which was established in 2014 within a mile of Olean's Café. With a newly renovated dining room Earley's Kitchen is a modern take on soul food and customers often stay longer, which has a direct correlation with consumption. Further, Earley's Kitchen is highly rated on all major rating websites.

In an effort to collect accurate data we arrived at Olean's café and purchased a meal or food item. This was our attempt to assimilate and not draw attention to our effort to collect data. We observed the customers and staff

ARRIVAL INTERVAL OBSERVATIONS

10	4	0	1	3	0	1	7	2
0	7	0	0	2	1	0	1	3
0	4	0	1	3	2	6	8	1
7	0	0	0	0	1	5	0	1
4	0	5	10	6	1	4	2	4
0	0	0	7	0	6	10	0	0
			Total	=144		Mean	= 2.62 Min	

interaction on numerous occasions.

We met with Olean McCaskill, the owner of the restaurant as we were nearing the end of the observation to discuss the specifics of their supply chain management. We were greeted, understandably so, with hesitation and questions about the research we were conducting.

3. Supply Chain

The Olean's restaurant has three suppliers, Ron Hard Food Services, Capital Seafood, and Coca Cola. According to the owner Olean, McCaskill Capital Seafood delivers fresh seafood daily while the other two suppliers deliver goods once a week. The owner stressed the importance of not only having but also serving fresh seafood to their customers.

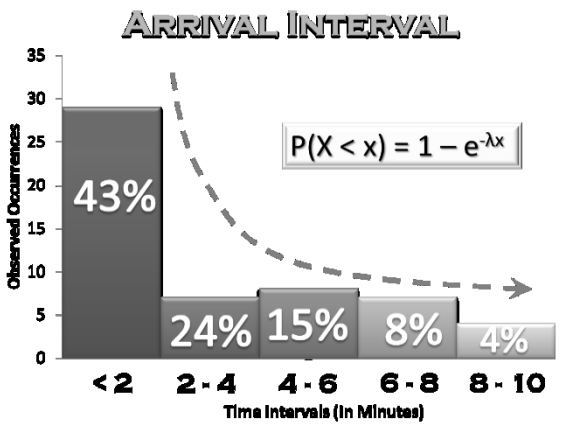
4. Method of Data Collection

In the first session of data collection we strictly monitored customer arrival, and departure times. Again this was done without interacting with customer. We monitored the door information to help us discern customers.

In the second session we applied the same methodology. We went into the restaurant to make a purchase and sat as we collected the data. In this session however we monitored the service times, queue times as well customer arrival and departure times.

Each member of the team was tasked with monitoring and collecting data for all the subsections. We then compare data to minimize errors and erroneous numbers.

5. Customer Observation



By making observations at Olean's cafe we were able to determine the arrival time, the average amount of time spent in service by customers, and make some observations about customer demographics. We determined this data through direct observation. Our observations also revealed that nearly 93% of the customers where African American males and females.

6. Data Classification

Null Hypothesis: customer inter-arrival time is exponentially distributed.

Alternate Hypothesis: customer inter-arrival time is not exponentially distributed.

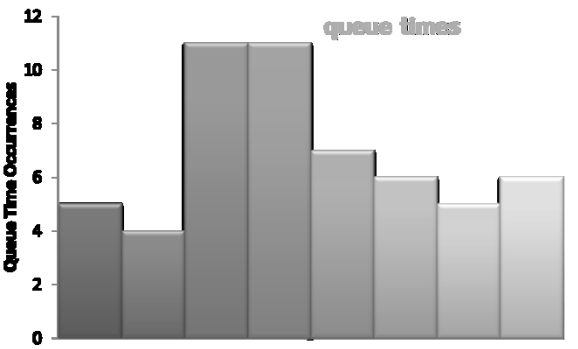
TIME IN QUEUE OBSERVATIONS								
5	2	5	3	1	1	2	4	8
4	2	8	5	2	6	2	6	6
3	3	10	0	2	2	3	2	0
3	4	5	0	3	4	3	9	1
3	4	6	1	2	5	3	4	2
2	5	6	10	0.5	4	10	3	0
			Total	=144		Mean	= 3.68 Min	

In order to determine the proper customer arrival and service time distribution at Olean's Cafe, we performed a Chi square goodness of fit test. For the service times we plotted a histogram and formulated the following hypothesis:

Null Hypothesis: customer service time is normally distributed.

Alternate Hypothesis: customer service time is not normally distributed.

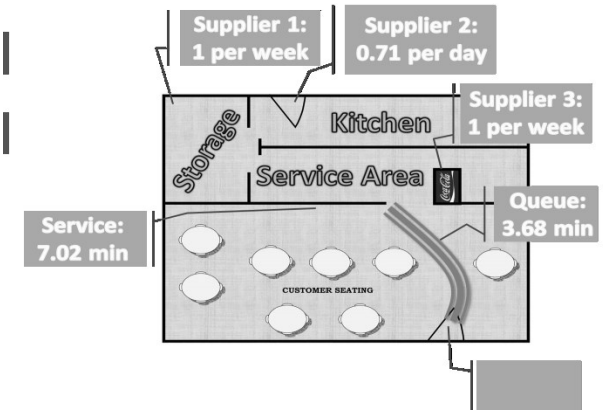
Customers enter at the waiting area prior to making it to the hot bar. The service process began once the customer reached the hot bar. At the hot bar, the customer tells the server which items he or she wants (from the items listed on the hot bar menu), and if they want any additional specialty items such as pancakes, waffles, cinnamon rolls etc.



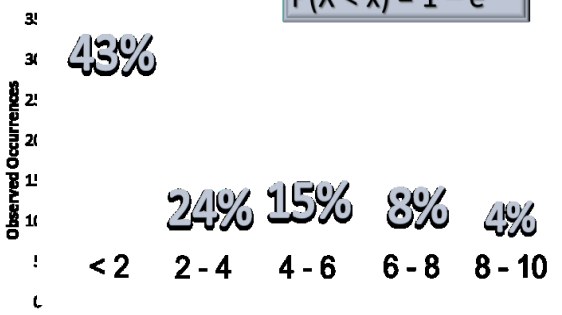
The order is then fulfilled, starting immediately with the products on the hot bar that packaged. Specialty items are then added. Based on our observations the service rate is 0.15 transactions per minute. That is, a service time of 6.67 minutes. The customer arrival rate is 0.283 arrivals per minute. That is an inter arrival time of 3.53 minutes. Based on these observations, the average service time was longer than the average customer interval

arrival time. Therefore, the team recognized that the length of the queue will grow to infinity. The simulation should demonstrate this phenomenon.

7. ProModel Supply Chain & Suppliers



$P(X < x) = 1 - e^{-\lambda x}$



Service Times Observations

SERVICE TIMES OBSERVATIONS								
5	2	5	3	1	1	2	4	8
4	2	8	5	2	6	2	6	6
3	3	10	0	2	2	3	2	0
3	4	5	0	3	4	3	9	1
3	4	6	1	2	5	3	4	2
2	5	6	10	0.5	4	10	3	0
			Total	=202.5		Mean	= 3.68 Min	

Chi Square Test

#	Interval	Observed	Expected	Oi - Ei	(Oi-Ei)^2 /Ei
1	< 0.72	5	6.75	-1.75	0.45
2	0.72 – 1.95	4	6.75	-2.75	1.12
3	1.95 – 2.86	11	6.75	4.25	2.68
4	2.86 – 3.68	11	6.75	4.25	2.68
5	3.68 – 4.5	7	6.75	1.75	0.45
6	4.5 – 5.41	6	6.75	-0.75	0.083
7	5.41 – 6.64	5	6.75	-1.75	0.45
8	6.64 <	6	6.75	-0.75	0.083
				Sum =	**7.996**

#	Interval	Observed	Expected	Oi - Ei	(Oi-Ei)^2 /Ei
1	< 3.5	5	6.75	-1.75	0.45
2	3.5 – 4.95	4	6.75	-2.75	1.12
3	4.95 – 6.04	20	6.75	13.25	26
4	6.04 – 7.02	6	6.75	-0.75	0.083
5	7.02 – 8	6	6.75	-0.75	0.083
6	8 – 9.09	3	6.75	-3.75	2.08
7	9.09 – 10.54	3	6.75	-3.75	2.08
8	10.54 <	8	6.75	1.25	0.23
				Sum =	**32.126**

λ: 0.283 Customers per minute
μ: 0.15 Customers per minute
K: 5
Standard Deviation: 3
Degree of Freedom: 3
Critical Value: 7.815

8. Forecast

We ran simulations for forecast values of arrival times base on forecast future values. The forecasts obtained from the Fourcast (2016) time series analysis and forecasting computer program. We did not have an historical record of demand for the company. So, we forecast

ARRIVAL INTERVAL FORECAST

QUARTERS	GDP FORECAST	% Δ	BETA FACTOR	FORECAST ARRIVAL
Q4 – 2015	*1816.480*	--	--	*2.62 min*
Q1 – 2016	1821.804	0.2%	0.152%	2.624 min
Q2 – 2016	1843.527	1.2%	0.912%	2.648 min
Q3 – 2016	1858.587	0.8%	0.608%	2.664 min
Q4 – 2016	1870.144	0.62%	0.47%	2.677 min

gross domestic product (GDP) obtained from the U.S. Bureau of Economic Analysis (2015), and used the forecast GDP to estimate Olean's future inter arrival times. The input data were quarterly GDP. Based on the quarterly forecasts, four simulations were constructed.

We used Promodel to simulate the supply chain with exponentially distributed arrival times and normally distributed service times. Based on the simulation we were able to recommend improvements for the company. After placing the data in ProModel we concluded with the following: extremely long queue times remained, average service times increased and the restaurant maxes out the current systems capacity.

9. Restaurant Recommendations

There are several recommendations in which we would recommend to Olean's Café in an attempt to appease customer's interpretation of speed of service time at the restaurant.

The first would be the utilization of digital imagery via a local business 'Captive Eyes.' Captive eye mounts television (TV) sets in the business at no cost to the business and generates revenue by running ads on the TV. Using such services, the customers will be distracted from the excessive service wait time.

The Second recommendation would be adding additional employees to the hot bar, Olean's Café could also implore additional employees to help process specialty items while the customers are waiting. This will help to reduce wait times.

Finally, The Olean's Restaurant should expand at least an extra 200 square feet. The restaurant building itself is very small. The new space should be utilized to create two counters at the hot bar, one for the specialty items and the other for the hot bar. Having two counters would allow for a more fluid experience and lower wait times.

While the goal of any business is to generate revenue, the most important individual in the equation is the customer. Any of these recommendations would provide for better customer service.

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Heuristic Evaluation of an In-Car Navigation System

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Abstract

Drivers today often rely on in car navigation systems to guide them. Although such a system can provide convenience and ease, it can also create hazard to the driver if not properly designed. Therefore, the usability of an in car navigation system is very important. This study conducted a heuristic evaluation on an in car navigation system to identify usability problems for the system. Three evaluators examined the interface and reported usability problems. Design recommendations were provided to help improve the navigation system.

1. Introduction

In car navigation systems have become an essential part of the driving experience. The introduction of such systems brings relief to the anxiety of the drivers about navigating the roads, especially when they are in an unfamiliar place. In the past, some accidents occurred when the driver tried to use maps to navigate and got distracted from driving. In car navigation systems such as a GPS device provide an easier and safer alternative to navigate. With the development of modern technology, in car navigation systems today provide more than just electronic maps. They have a lot of features such as Bluetooth connection, voice command that bring more convenience to the drivers. However, the use of the in car navigation system can also introduce new risks to the driver. For instance, operating the system while driving could be very dangerous. There is also the issue of the accuracy of the maps. Many systems require the customer to pay for updated maps and an outdated map can take the driver to an incorrect location or even worse, can lead the driver to an unsafe place. Another concern is the availability of the GPS signals. Without sufficient signals such as between tall buildings in a large city, the navigation could be very difficult.

Even if the maps are accurate and the GPS signals are strong, there are still questions such as “Will people be able to use it effectively?”. Hence, in addition to the utility aspect of the in car navigation system, there is another aspect of the system that needs to be investigated. That is the usability of the in car navigation system. ISO 9241-11 [1] defines usability as “the extent to which a product can be used to

achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use."

Usability concerns are often addressed using various attributes. One of the commonly accepted list of attributes was proposed by Nielson [2]. Table 1 lists those attributes.

Usability evaluation can be done in different ways. One approach is to conduct usability testing where actual users will be recruited and perform tasks. However, it takes time and could be very expensive. Alternatively, discount usability evaluation techniques can be cheap and effective. One of the discount usability evaluation techniques is heuristic evaluation. Heuristic evaluation only requires a small number of evaluators to go over the product and evaluate the interface based on well accepted heuristics. Table 2 provides a list of widely used ten heuristics developed by Nielson [3, 4].

Typically, three to five evaluators with experience in usability evaluation would be used. It is not recommended to use just one evaluator to perform a heuristic evaluation since the proportion of the usability problems that can be found by a single evaluator will be limited. However, more than five evaluators are not recommended either since only little information can be gained comparing to the cost and time when more than five evaluators are used.

TABLE I. NIELSEN'S TEN USABILITY HEURISTICS (2012)

Attributes	Definition
Learnability	To what extent can a user accomplish basic tasks the first time they use the system?
Efficiency	How fast can users use the system to perform tasks once they have learned the design?
Memorability	How easily can a user regain the proficiency after they have not used the system for a period?
Errors	How many errors do users make, how severe are there errors, and how easily can the recover from the errors?
Satisfaction	How pleasant is it to use the design

TABLE II. NIELSEN'S TEN USABILITY HEURISTICS (1995)

Usability Heuristic	Description
Visibility of system status	The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
Match between system and the real world	The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

User control and freedom	Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
Consistency and standards	Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
Error prevention	Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
Recognition rather than recall	Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate
Flexibility and efficiency of use	Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
Aesthetic and minimalist design	Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
Help users recognize, diagnose, and recover from errors	Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
Help and documentation	Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

It needs to be pointed out that heuristic evaluation can complement with usability testing and should not be used to replace it.

Once the evaluators detect the usability problems of the interface, severity ratings are assigned to the problems. In addition, the ease of fixing rating is also provided. Table 3 provides the list of severity rating introduced by Nielson [5]. The ratings are in the scale of 0-4 with 4 being the most severe. Table 4 provides the ease of fixing rating [6]. The ratings are in the scales of 0-3 with 3 being the most difficult for a team to fix the usability problem. Typically, a heuristic evaluation can be done in four phases: training, evaluation, rating and debriefing.

In this study, a Garmin GPS system was evaluated for its usability problems. The model of this in car navigation system is Garmin NuviCam LMTHD GPS and Dash Camera. This system has 6" glass display. It has a dash camera integrated with the GPS unit. It provides free lifetime map updates. In addition, this system provides alerts for front collision warning and lane departure warning. Another feature is the real time camera view when approaching the destinations. Figure 1 provides a picture of this in car navigation system.

The reason this particular model was selected is because Garmin GPS systems are very popular and are widely used by the drivers.

FIGURE 1. GARMIN NUVICAM LMTHD GPS AND DASH CAMERA

TABLE III.NIELSEN'S SEVERITY RATINGS (2003)

Severity Rating	
Rating	*Definition*
0	No usability problem at all
1	Aesthetic problem that required easy fix if time is available
2	Minor usability issue: fixing is of low priority
3	Major usability problem and fixing requires high priority
4	Usability catastrophe: needs to be resolved prior to product release

TABLE IV. OLSON'S EASE OF FIXING RATINGS (2004)

Ease of Fixing Rankings		
Rating	*Description*	*Definition*
0	Extremely easy to fix	Problem would be extremely easy to fix. Could be completed by one team member before next release.
1	Easy to fix	Problem would be easy to fix. Involves specific interface elements and solution is clear.
2	Some effort to fix	Problem would require some effort to fix. Involves multiple aspects of the interface or would require team of developers to implement changes before next release or solution is not clear.
3	Difficult to fix	Usability problem would be difficult to fix. Requires concentrated development effort to finish before next release, involves multiple aspects of interface. Solution may not be immediately obvious or may be disputed.

2. Method

Three graduate students who had usability evaluation experience conducted the heuristic evaluation. All of them had experience using the Garmin GPS systems although none of them had experience using this particular model.

Each of the evaluators was briefed about the system and was informed to use Nielson's ten heuristics to evaluate the system.

Each evaluator assessed the system independently. Usability problems were identified, severity rating and ease of fixing ratings were assigned.

Upon completion, all evaluators convened to discuss the findings. Each usability problem was examined for where it occurred, the heuristics it violated, the severity rating of the problem, the ease of fixing rating of the problem, and the potential solution or fixing the problem. After the consensus was achieved, a final list of usability problems was provided along with severity ratings and ease of fixing ratings.

3. Results

Overall, evaluators found a total of 25 usability problems. Three heuristic violations, "user control and freedom," "error prevention", "visibility of system status", and "Aesthetic and Minimalist Design", accounted for 80% of the problems.

Figure 1 shows a breakdown of the problem totals by heuristic violation.

Table 5 provides the top ten usability problems identified.

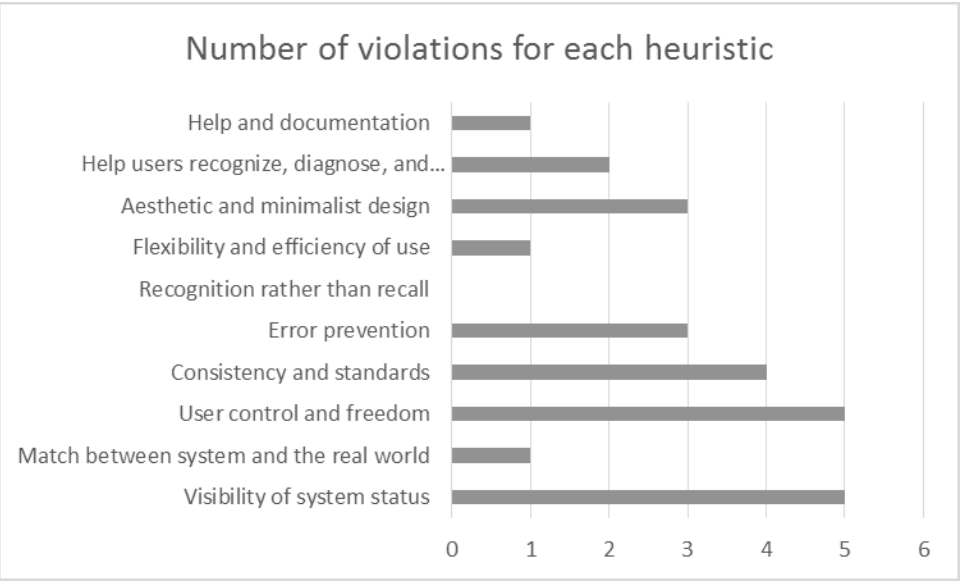

FIGURE 2 NUMBER OF VIOLATIONS PER HEURISTIC

TABLE V HEURISTIC EVALUATION RESULTS

Usability Issue	Heuristic Violated	Severity Rating	Ease of Fixing
No emergency exit for some of the screens	User Control and Freedom	3	1
GPS can get into a long loop when searching for some destinations	Error prevention	3	2
Voice command sometimes can be frustrating	Error prevention	2	2
Some of the screens are very cluttered	Aesthetic and Minimalist Design	2	1
No indicators of GPS signal for some of the screens	Visibility of System Status	2	1
No indictor of battery life for some of the screens	Visibility of System Status	2	1
No indicator of how deep in the menu	Visibility of System Status	2	1
The Camera move sideways for adjustment, and not up and down	User Control and Freedom	2	2

Blank card in the second slot not recognized. It seems that only the primary slot can format your card.	User Control and Freedom	2	2
Certain buttons (i.e., back) were located differently on some of the screens	Consistency and standards	2	1
Cannot save your current location in memory.	Consistency and standards	2	1
The lane and collision warnings are only as accurate as your alignment of the camera.	Consistency and standards	2	2
No corrective actions for front collision and lane deviation	Help Users Recognize, Diagnose, and Recover from Errors	2	2
The connection cable is short and fat and difficult to hide	Aesthetic and Minimalist Design	2	1

4. Discussion and Conclusion

A heuristic evolution was conducted on an in car navigation system. Using Nielson's ten heuristics, three evaluators identified 25 usability problems. Although majority of these problems are not serious reflecting and yet considering the importance of safety in driving, those problems should be addressed. Fortunately, most of those problems are not difficult to fix.

Findings from this study again proved the importance of heuristic evaluation. In the future, usability testing that uses actual users still need to be conducted and results of heuristic evaluation can complement the formal user testing.

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Ergonomic Assessment of Risk Factors in Tree Pruning

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Abstract

In the tree care industry, dozens of fatalities occur each year and the rate of accidents resulting in lost work time was documented to be four to five times higher than all-industry averages. One of the leading causes for fatalities is falls. The industry standard does not require arborists to be tied-in twice when using handsaws. This could lead to the climbing rope being cut accidentally by the handsaw used in tree pruning, resulting in a fall accident. This study focuses on the human factors of tree care workers. Three local companies with ISA certified arborists were surveyed and results identified common work practices, safety concerns, and risk factors in tree pruning.

1. Introduction

Tree care is one of the most dangerous industries and a lot of people are not aware of it. Accidents in the tree care industry can range from injuries resulting in lost work time to fatalities. The fatal accident rate among arborists is about 10 times the average for all industries [1]. There is a long history of tree care accidents. Back in 1972, lost time caused by the tree care industry accident was four to five times higher than all-industry averages [2]. Arguably, felling a tree is one of the most dangerous activities in America. In the tree care industry, one of the leading causes for fatalities is falls. In 1992, the National Institute of Occupational Safety and Health (NIOSH) reported on average, about 20 workers in the tree care industry were killed each year where falls were one of the two leading causes (the other being electrocution) [3]. In 1995, 40 fatalities occurred in the tree care profession with 13 caused by falls [4]. In another study, it was reported that there were 1285 fatalities in tree care industry during 1992--2007, an average of 80 deaths per year, and 23% of those fatalities occurred in tree felling [5-6]. Government reports show that falls are one of the leading causes for the death in tree care industry. Unfortunately, this trend continues. In 2012, 84 fatalities in tree care industry were reported and in 2013, the number is 79. Those numbers are conservative estimates since not all fatalities were reported [7-9].

Another concern is the use of handsaw. The industry standard (Z.133) does not require arborists to be tied-in twice when using handsaws even though they are required to do so when using chainsaws [10-11]. Without the proper protection, a fall accident can occur when the climbing rope is cut accidentally by the handsaw used in tree pruning [10-11]. In

2009, an accident occurred in Georgia, where an experienced tree worker completely cut his rope with a handsaw, fell out of the tree, and broke his neck, resulting in quadriplegia [5].

Researchers investigated the risks of these types of accidents where the rope and the handsaw blade have already made contact and examined the likelihood of rope failure associated with rope and blade types, as well as rope tensions and impact forces [10-11]. They cautioned that it is unclear how closely their testing approaches simulate the real situations.

Kane et al. examined how various combinations of handsaw blade and rope types affect the likelihood of rope failure resulting from the contact between the blade and the rope [10]. Later they included two additional factors in this risk assessment: rope tension and blade impact force [11]. The rope tension can vary wildly depending on the work phase, swinging of the climber, and lanyard or spike uses. The impact force imposed by the handsaw blade on the rope vary from full force exerted by both hands after prematurely severing a branch, to lighter impact when returning the handsaw to its scabbard. The authors pointed out that it is unclear how closely the maximum impact force they tested simulates the actual force exerted by a worker as he or she cuts through a branch. They conjectured that a greater risk would occur when a tree care worker is making a cut but unaware the rope is in the path of the saw blade. In addition to this "rope awareness" factor, they suggested future work also investigates the effects of blade design (e.g. tooth design, tooth per inch, and curvature) on rope-cutting efficiency. The only other study found related to ergonomics and safety in handsaw uses in the arboriculture industry is done by Mirka et al. [12], where an empirical study was conducted with recruited human subjects to investigate the effect of arboriculture handsaw type on the productivity and muscle exertion levels in the upper limb.

In addition, no systematic research studies exist that study fall risks in arborists from a human factors perspective to help find effective ergonomics and safety solutions.

Before conducting any empirical experiments in the lab settings, it is important to gain a good understanding of the common practices, safety concerns, and risk factors in tree care industry. Therefore, studies need to be conducted to address this concern.

2. Method

To achieve this goal, a survey was conducted. An application was submitted to the Institutional Review Board (IRB) at North Carolina A&T State University (NCA&T) and the study was deemed exempt. Ten local tree care companies in the piedmont triad area of North Carolina that provide services of ISA certified arborists were contacted via email or phone. They were briefed of the purpose and basic scope of the research. Three ISA certified arborists from three companies agreed to participate in the survey via a telephone. The entire session lasted about half an hour. Notes were taken during the phone call and entered into an Excel sheet later. No personal or identifiable information was recorded or saved.

One of the companies also agreed to be observed during a pruning session that lasted about four hours. Informal interviews were conducted with the tree care workers to help identify their safety concerns and perceived risk factors.

3. Results

Notes taken during the interviews were separated into one of the following categories:

Common practice, safety concerns and perceived risk factors.

Tables 1-2 provide the summary of the findings of each category.

Table 1: Common practice identified from the survey

Work Site Assessment
• Check the ground • Check the surroundings • Check the overhead objects
Assessment of the tree to be pruned
• Inspection needs to be done by a certified arborist • Assess tree conditions • Identify fall hazards • Falling object hazards • Hazard assessment
Climb or use aerial lifts ○ Ladders ▪ Make sure no defects ▪ Maintenance ▪ Location to place the ladder ○ Aerial lifts ▪ Well maintained ▪ Protection equipment
Worker training • Techniques to climb a tree • Protective equipment
• Fall protection
Worker protection • Protection gears • Fits well • Protection from fall • Protection from overhead falling objects • Workers familiar with the gears • Climbing line • Safety lines • Power lines • Drop zones
Communication • Between overhead crew and the ground • Use visual and voice
Traffic Control
• Transportation • Struck by a truck
Emergency
• Contact • Retreat path

Table 2: Safety concerns and perceived risk factors

Contact
• Falling branch • Entire tree • Chainsaw
• Cuts • Cuts on the rope • Caught in a chipper • Failed communication system • Miscommunication between overhead and the ground

• Electrical contact
  ▪ Unware of the power lines
  ▪ Training
  ▪ injuries

Falling techniques
• From a tree • From an aerial lift • From a ladder • Disconnect the protection
Structural integrity
• Internal decay • Struck by the tree • Hidden defects • Uncertain where the tree will fall • Notched tree very dangerous • Don't stand in front of a notched tree
Repositioning
• The lanyard is unsnapped • Worker unsecured
Chainsaw
• Cut the climbing line • Lanyard • Lost balance • Cut anchor point • Improperly tied knot
Aerial lift failure
• Boom/cable snaps • Cylinder fails
• Check it before each work • Maintenance
Equipment/trucks
• Maintenance
Environment

• Dogs
• Bee stings
• Harmful
• Electric shock
  ▪ Direct contact
  ▪ Indirect contact

Worker training
• Distracted/not focused • Job set up • Worker not properly secured • Chainsaw worker inexperience • Directional tree felling

4. Discussion and Conclusion

Tree care is one of the dangerous industries. Tree care workers are facing much larger risk than some other occupations. The findings from the interview of three local companies confirmed this and also revealed the importance of protocol, training, and protection. All three companies emphasized the necessity of the protocols since there are too many ways a tree worker can get hurt. It is also clear that falls are the most common type of accidents among the companies.

Safety concerns and risk factors were also identified from this study. It is clear that more needs to be done to improve worker safety in

the tree care industry. Although risk factors were identified from this study, the specific impact of those factors on the workers are not clear. Therefore, it is important to investigate them. Specifically, empirical study where human participants are utilized in tree pruning task may be needed.

One of the limitations of the current study is the small size of the sample. Only three local companies were surveyed. In the future, more companies need to be surveyed to get a better and clearer picture of the problems workers face in the tree care industry.

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Human Factors in Agile Manufacturing: Developing the Existing Workforce

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Abstract

This study was designed to determine if there is a relationship between job automation, worker satisfaction, and worker stress load which can be deterrents for the workforce within an agile manufacturing process. 86 workers from 28 different manufacturing facilities were interviewed. Human/machine interaction, process improvement, and workload were found to be the top three reservations for current workers. This study also includes a systematic review of the literature that spans the larger picture of how agile manufacturing strategies are leaving out the human resource development which is the core of making industries more successful. Also probes for more specific findings on how strong skills can be developed in specific groups of workers who are exposed to training that is indicative of these human factors. The literature review sought to analyze these questions: 1) Is job profiling in manufacturing related occupations important? 2) How does the agile manufacturing organizational model affect human resource development? 3) What additional human factors should be focused on, other than the skills gap, in workforce development endeavors? The analysis contributes to the investigation of the three gap phenomenon, the skills gap, incentives gap, and interest gap, which is thought to contribute to the overall success of workforce development efforts. With the rise in college enrollment, government programs, and marketing studies, industries are still seeing a shortage of skilled workers which makes this study and literature review a valuable asset for conceptualizing possible solutions.

1. Introduction

Although the definition of manufacturing is the same today as it was centuries ago when the term was first coined, the means to the end product has drastically transformed. Modern industries boast of providing a 'Human Network' (Cisco, 2008) or being 'Strategically Balanced for Growth' (Curtiss-Wright, 2014). These expressions are more than just taglines; they try to envelope the essence of manufacturing in the current global market. Agile manufacturing is the idiom used to describe the wide scale efforts industries implement to ensure sustainability of their products and services. What does this singularity mean in today's economy? Furthermore, what does it mean for the current market and the common consumer? How have companies become more flexible in facilities design, business practices, and product development? Most importantly, what kind of role does agile manufacturing play in current strategies for workforce development?

With manufacturing contributing about 20% of the total Gross Domestic Product in the US and much more in other developed countries, provisions should be made when issues arise (Kalpakjian & Schmid, 2008). In 2014, 64% of manufacturers surveyed expected revenue growth and 75% reported actually experiencing growth. When questioned about hurdles in growth, 46% named the economy as their greatest hurdle, and 18% reported a shortage of skilled workers (ASQ, 2015). In 2015, 83% of manufacturers surveyed forecasted an expected

revenue growth. Again, when questioned about hurdles, 41% named the economy as their greatest hurdle, and 26% reported a shortage of skilled workers (ASQ, 2015). The large majority of employers report that they cannot find workers with the right skill sets. They also report issues with soft skills such as working on a team, reading, and interpreting technical data, among others. To help find solutions to local workforce development issues, workforce development boards, colleges, and universities are involved in grant projects related to specialized training to increase skills in their regions. These grants do not include the thousands of dollars spent in economic incentives, customized training, and on-the-job training dollars that comes from state governments. Millions of dollars are being funneled through grant programs or other initiatives to help develop the workforce. Based on research and current reports, the best use of these dollars seems yet to be determined.

Companies have grasped the agile manufacturing concept as an established organizational paradigm that, in principle, should contribute to developing their workforce from within (Alves, Dinis-Carvalho, & Sousa, 2012). Plant managers, engineers, business officers, and marketing personnel are taught that the concurrent design process should be laced with flexibility while making quality products. Is there really a skills gap, or are companies moving so fast with the agile manufacturing concept that they, themselves, cannot keep up with their own changes? How can a worker be trained for a job description that is non-existent, or how can a company ask for an employee when they are not sure what skills they need? Much research is put forth in creating a vibrant, flexible, and sustainable plant layout where the goal for instrumentation and controls is to make the environment more user-friendly and manageable on a larger scale (Fekri, Aliahmadi, & Fathian, 2009). As reflected in the previous reference to the taglines, most companies proclaim their success or failure to be directly connected to their employees. While workforce dynamics is a fluid subject with many subtleties to consider, the focus of this paper is to examine the commonalities in the prior research to discern the direction of future strategies, particularly in human factors related workforce development in manufacturing. Chiefly, the focus of previous research points to the low skilled worker as the setback for industry today; however, the idea of the three gap phenomenon, the skills gap, the incentives gap, and the interest gap, is actually a better representation of the problem (Thompson, McGraw, & Hair, 2015).

Thompson, McGraw, and Hair (2015) propose a culmination of gaps in the current workforce, worker skill, the interest of the future workforce, and the incentives provided by current employers, as cause for the current state of workforce development. Common characteristics connect the interest gap, incentives gap, and skills gap to make one active system that contributes to overall success of the manufacturing industry. These characteristics include industry engagement, social networking, community involvement, applied knowledge and experience, innovation and problem solving, and interaction with the environment, all of which are innately human factors. The purpose of this study was to provide insight on how the progression of industry practices and increased automation has affected the conventional worker and to observe common factors that companies have initiated as part of the agile manufacturing process that may relate or contribute to the nature of human factors specific to behavioral and cognitive research.

2. Literature review

This literature review is meant to inform the reader about the value of human factors in workforce development and how pinpointing specific factors can help create a training environment more conducive to actual job requirements, not just perceived requirements. The literature review spans the larger picture of how workforce development is related to human factors in engineering, and also probes for more specific findings on how strong skills can be developed in specific groups of workers who are

exposed to training that is indicative of these factors. The review seeks to analyze these questions: 1) Is job profiling in manufacturing related occupations important? 2) How does the agile manufacturing organizational model affect human resource development? 3) What additional human factors should be focused on, other than the skills gap, in workforce development endeavors? The analysis contributes to the study in that the findings support a focus on engagement with employees. With the rise in college enrollment, government programs, and marketing studies, stakeholders are still seeing problem areas which makes this study a valuable asset for conceptualizing possible solutions.

Is job profiling in manufacturing related occupations important?

The results were actually unveiled in a linear format supporting the assumptions of the three gap phenomenon (Thompson, McGraw, & Hair, 2015). Companies are often at a loss as to how to train their employees, what types of training their employees actually need, and what skill sets their employees should actually have to be successful at the positions in question. In most cases, companies cannot even produce job descriptions for positions in which they wish to fill. Mardar (2010) conducted a mixed quantitative and qualitative study that analyzed 105 on-line job ads and compared the ad descriptions to the knowledge, skills, and abilities defined in occupational standards. Mardar found "six major categories of requirements referring to: 1) general abilities (not related to a certain profession); b) the required behavior and attitude; c) communication, social or group competencies; d) mental skills; e) psycho-pedagogical and methodical knowledge and abilities; f) other requirements, not classified in the previous categories" (p. 136). The key terms indicated in the descriptions were based mainly on soft skills. Many employers listed characteristics such as "open to change" or "adaptable" (Mardar, 2010).

In manufacturing, more training is directed at specific technical skills with soft skills expected to be an inherent quality the worker already possesses. Technical education is especially important to the economy in developing and developed countries (Wallenborn, 2010); however, companies are reporting a downfall in soft skills and other liberal studies type requirements. Jaschik (2015) examined work readiness perceptions of recent graduates now working in their fields and their employers on how well the former students were prepared for their positions. The findings indicated that graduates thought highly of their own soft skills, whereas, employers ranked them much lower in every attribute surveyed from teamwork to awareness of diverse cultures. This inventory reinforces the need for straightforward communication of valid job profiles which can be an investment the company cannot afford in terms of human and monetary resources. With a valid job profile, employees and employers will know exactly what to expect in terms of job performance. Employers will then know how to support the professional development of their employees (Meyer, Stanley, & Parfyonova, 2012).

Preliminary findings indicated that when employees feel supported and valued in their job, they will perform better and exhibit higher job satisfaction even when the job is deemed more demanding (Van den Broeck, De Cuyper, Luyckx, & De Witte, 2012; Shuck & Wollard, 2008; Dinis-Carvalho & Sousa, 2012). Furthermore, demanding jobs were found to require more emotional engagement from the employee, and often times, these jobs were the medium to low skilled, and in many cases temporary, positions (Cheung & Lun, 2015; Glover, Farris, Van Aken, & Doolen, 2011). Employers following the agile manufacturing model incorporate lean policies that are actually promoting the use of temporary employment or multidisciplinary training leading to more demanding positions with little support because of lean operation (Glover, et al., 2011; Kara, Kayis, & O'Kane, 2002; Ragin-Skorecka, 2014). Companies implementing agile manufacturing

concepts are cherry picking the features they wish to implement such as Just In Time, but for the design to be successful all aspects of quality improvement must be precipitated (Alves, Dinis-Carvalho, & Sousa, 2012). Ragin-Skorecka (2014) discussed three aspects for agility, entrepreneurial, social, and financial. "Social agility is associated with the relatively free possibility to make changes in the configuration of human resources, depending on the opportunities emerging in the environment. It is related to three variables: competences, employment relationship, and the form of work organization" (p. 2). He argues that social agility is the most important of the three which points to the importance of constant, up-to-date job profiles so workers know their focus.

As in the case of mileage efficiency in an automobile, a gallon of fuel has only so much capacity for producing energy. Efficiency has limitations. This review would be amiss if limitations in humans were not mentioned. Information Theory considers a measure for determining information processing humans undergo, but it is lacking in determining how much capacity a human can experience in individual sensory channels before exhaustion (Wickens, Lee, Liu, & Gordon-Becker, 2004). The results suggest that human limitations are met when there is constant change in the working environment without proper support and motivation. Workers face consequences of action when on task or failure to act when a situation changes. In reality, their perceptions may differ from that of their employer because they do not fully understand the system as a whole. Workers are limited by their knowledge and experience making it the employer's job to guide them to understanding. What seems to be brought to light from the research is that the very theories of good business practice that are known to advocate for the worker as the most important resource are not being fully implemented.

How does the agile manufacturing organizational model affect human resource development?

In the agile manufacturing model, continuous process improvement and technological upgrades can cause unrest among some employees due to feelings of uncertainty and ambiguity in their job profile (Kaufman & Bernardez, 2012; Large & Kenner, 2012). Employees with higher intrinsic motivation were more likely to accept change and perform optimally on a given task; however, job loss or restructuring were found to lead to long term insecurity which can demoralize even the highly motivated individuals (Kinnunen, Mäkikangas, Mauno, De Cuyper, & De Witte, 2014; Meyer, Stanley, & Parfyonova, 2012). Another costly area of investment for employers is on-the-job training. Agile manufacturing promotes the use of employees at all levels to be a part of the decision making process (Alves, Dinis-Carvalho, & Sousa, 2012). Particularly, for new employees, jobs can be demanding and emotionally exhausting which can lead to turnover.

While demanding jobs can make employees feel more motivated, it can also lead to burn-out if there is not proper support. Van den Broeck, De Cuyper, Luyckx, and De Witte (2012) studied job characteristics at a variety of different functional and structural levels within a large organization. They found "demanding jobs were most prominent among part-time and lower ranked employees, that is, blue-collar workers and administrative personnel and job resources may fully buffer the health-impairing impact of high demands" (p. 699). Upon further study, employees who obtained these demanding positions were likely to be younger or much older workers. These workers were found to have less intrinsic motivation to be successful (Van den Broeck, Lens, De Witte, & Van Coillie, 2013). On the flip side, companies that lose employees after strategic training do not see a return on their investment (Tessema, Winrow, & Teclezion, 2012). Justifying long term training for human resource development can be complicated for high turn-over positions.

Using robotics and automated controls can be a more reliable investment even with the high initial costs of implementation (Ng, Duffy, &

Yucel, 2012). Automation can improve facility design and production, but it also changes the way workers do their jobs. Companies must be careful to take precaution when implementing automation. Roll outs strategic to changes in human behavior should be an adaptive process (Kaber, Wright, Prinzel, & Clamann, 2005). "Adaptive automation (AA) has been defined as the dynamic allocation of control of system functions to a human operator and/or computer over time with the purpose of optimizing overall system performance" (Kaber, et. al., 2005, p. 730). Even with an adaptive process, workers may require extensive training because of the new skill sets needed to be successful operators. Other factors such as safety and perception should be considered as well (Ng, Duffy, & Yucel, 2012; Kaber, et. al., 2005).

Companies are forced to make trade-offs concerning flexibility in their processes. "Manufacturing firms are under mounting pressure to respond to decreasing product life cycles and increasing product variety as demanded by customers" (Kara, Kayis, & O'Kane, 2002, p. 76). With this pressure, crucial decisions have to be made, and many times, it is the social piece that is let go. Companies fail to gauge and establish boundaries for information processing resulting in two scenarios: over taxation of their employees and/or failure to engage their employees. This practice has led to the incentives gap (Thompson, McGraw, & Hair, 2015). Appropriate communication and partnerships can help alleviate the burden, but it will take education and training to fully overcome this gap.

What additional human factors should be focused on, other than the skills gap, in workforce development endeavors?

The Academy for Educational Development (2011) defines the workforce as "the human side of supply and value chains and effective human resources development and labor skills integration are key factors in increasing production efficiencies and reducing cost inefficiencies" (p. 2). This definition is vital in understanding how the human is an integral, value-added part of the production process (Xu, Chaudhry, & Li, 2009). The shape of a country's workforce is directly related to the Human Development Index. "The Human Development Index is defined for every nation on the basis of the three basic factors that shape the lives of man - education, health and income" (Lama & Kashyap, 2012, p.240). Companies must initiate, develop, and sustain human social networks as part of the logistics process and successful academic and industrial supply chain management. Bottlenecks or disconnects in an organization or partnership can be similar to a dysfunctional production process (Cross & Parker, 2004). The social network has to encompass all stakeholders to be successful. These stakeholders include the employer, current employees, future employees, and all the entities that take part in training and supporting human resource development. Even before the face of manufacturing changed completely, Branscomb, Kodama, and Florida (1999) forecasted this reliance as part of the overall economic good of the global market. They stated that,

> "If nations and regions are really serious about building the capacity to survive and prosper in the knowledge economy and in the era of talent, they will have to do much more than simply enhance the ability of the university to transfer and commercialize technology. Regional partnerships will have to act on this infrastructure both inside and surrounding the university in ways that make places more attractive to and conducive to talent" (p. 607).

Many institutions have stepped up to create valuable employee training tools. The models for workforce development are wide spread and as a future research recommendation, based on the exploration of focus within this literature review, a comparison of the more renowned developments over the last three decades should be conducted to determine an updated model for a human factor, person-centered approach. Third-party credentials or industry

recognized certifications have become more prominent as a technical training tool, and in some ways, human resource development has followed suite. Carliner (2012) sees the importance in standardization of training and development and outlines the common certifications companies can use as a valid option.

One sophisticated tool is the Career Readiness Credential offered by ACT (2011). ACT is in the unique position of having a proprietary skills database, JobPro, a national repository of occupational skill and task data for more than 18,000 jobs that have been profiled over 17 years (p.8). The data from the profiles comes from direct observation of physical tasks and apparent physiological tasks required for job performance. The tasks are then categorized among knowledge, skills, and abilities an individual should have to be successful at a particular position. In NC and many other states that have adopted the Career Readiness Credential, workers can be asked to complete a 'Career Readiness Certification' (CRC) which is also known as Work Keys. The CRC is a test with multiple aspects, but the three most common are 'Locating for Information, Reading, and Math' (ACT, 2011). The certification exam questions are tied into the tasks most common in the workplace which is the same task list that the profiler uses to document worker activity. By having a valid profile, a company can create a valid job description that requires workers to be certified at a certain level in the CRC. Without a valid profile, companies can only request workers to take the CRC. If a company does not hire a worker because of his or her skill set, they can be liable by law if they cannot prove that worker does not have the skill needed to fully complete the job duties. In addition, companies who require testing in order to obtain a position must be careful in the liability if their test is not validated. This strategy is more difficult with the ever-changing processes in agile manufacturing.

Naturally, there has been a rise in the demand for education in the last two decades, but for a student to gain employability, degree attainment may not be enough. Modern industry is requesting more from potential employees by way of third party skill-related credentials and customized training. Colleges are now learning to supplement their courses with these outside credentials (Thompson, McDaniel, James, Peeler, & Hollifield, 2013). With so many areas of expertise, shopping for outside credentialing to incorporate into current programs can be perplexing. Colleges have to be aware of what their local business and industry needs are and have to analyze the most economical way to meet them without overloading instructors and support staff (Thompson, et. al., 2013). As with industry, traditional methods of education have required a more adaptable approach. Distance education has been established as a viable alternative to individuals who cannot commit resources to being on campus (Lama & Kashyap, 2012). Distance programs can provide instruction in specialized skills and can be customized to fit the needs of the population. While universities are a direct link to advanced research and development, community colleges or technical schools tend to reserve their use to front line strategies for providing employers real-time training for their needs today (Mihei, 2013).

3. Method

This study was initially design to determine if there was a relationship between job automation, worker satisfaction, and worker stress load which as seen in the review of the literature can be deterrents in the agile manufacturing process. For the study, 86 workers from 28 different manufacturing facilities were interviewed. The workers were from various departments and ranks of employment. The manufacturing facilities varied in type as well. The workers were asked demographic questions of: Age; Gender; Years of service at the current company; Years of service at the current position; Do you feel this position has a low level of automation, mid-level of automation, or high level of automation?; How many hours of training did you receive prior to working this position on your own?; How long

has this position been in the company?; How many tasks do you have to complete at one time while you are performing your job duties?; Describe your job functions/duties; What would you do to make this job work more smoothly in the same environment?; and Does the automation in this position reduce or increase workload? The levels of automation were defined by using Wickens et. al. (2004) Levels of Automation Table.

Based on the findings of the literature review, 8 questions were developed to capture the feeling of satisfaction, engagement, and stress among the workers. The workers were asked to answer these questions on a scale of 1 to 5, 1 being you least agree and 5 being you most agree: Do you feel you have the ability to influence decisions that affect you or the process in this position?; Do you feel you have the ability to influence day-to-day company success?; Do you feel you have the opportunity to use new technologies?; Do you feel you can communicate with your supervisor about problems with your machine/job?; Do you feel like you have the support you need to be successful at this position?; Do you feel overwhelmed by the production rate on your machine/job?; Do you feel like you have the opportunity to advance in this position?; and Do you feel you are overall satisfied with your job? The workers were also given the opportunity to make additional comments at the end of the interview.

The selection of the interview pool was not a random process. Basically, the limitations were access and willingness of employees to be interviewed. Even with the limitations, the number of interviewees and different industries represented yielded usable results. The results were tallied in a spreadsheet and analyzed using Minitab. Descriptive statistics were obtained for each variable as well as an analysis of variances between select demographic variables of Hours of Training, Tasks Completed at One Time, and Level of Automation.

4. Results

The descriptive statistics for each demographic variable are listed in Table 1, and it is important to note that each variable was normally distributed.

Table 1. Descriptive statistics of variables

Variable	Number	Mean	StDev
Age	86	43.72	10.31
Yrs of service	86	11.81	9.29
Yrs at current pos.	86	6.72	6.30
Hrs of training	86	117.90	196.50
Number of tasks	86	4.82	2.94

Approximately 20% of the workers were female. Only 8% of the positions workers held were actually new (opened within the last two years) to the facility. The levels of automation reported by workers were divided into three categories, low, middle, and high. Again these levels were derived from Wickens et. al. (2004) Levels of Automation Table. The distribution of levels of automation were not significantly different. 27 workers reported a low level of automation in their position. 32 reported a middle level, and 27 reported a high level of automation. There was no significant difference in analysis of variances between the select demographic variables of Hours of Training, Tasks Completed at One Time, and Level of Automation. For the question,
Does the automation in this position reduce or increase workload?, 65% of workers felt a decrease in workload due to automation. 21% of workers said it neither increased nor decreased their workload, and 14% felt an increase in workload due to automation.

The results for the 8 questions about satisfaction and engagement are found in Table 2. The scale was 1 to 5 with 1 being least agree and 5 most agree. The results for each questions were also normally distributed. The questions are repeated as follows: 1) Do you feel you have the ability to influence decisions that affect you or the process in this position?; 2) Do you feel you have the ability to influence day-to-day company success?; 3) Do you feel you have the opportunity to use new technologies?; 4) Do you feel you can communicate with your supervisor about problems with your machine/job?; 5) Do you feel like you have the support you need to

be successful at this position?; 6) Do you feel overwhelmed by the production rate on your machine/job?; 7) Do you feel like you have the opportunity to advance in this position?; and 8) Do you feel you are overall satisfied with your job?

Table 2. Descriptive statistics of satisfaction and engagement questions

Variable	Mean	StDev
Q1 Influence decisions	3.51	1.29
Q2 Day to day success	3.71	1.16
Q3 New technologies	3.21	1.24
Q4 Comm. w/ supervisor	4.27	1.00
Q5 Support to be successful	3.81	0.93
Q6 Overwhelmed by prod.	2.55	1.22
Q7 Opportunity to advance	2.74	1.26
Q8 Overall satisfaction	3.80	0.96

Workers had the opportunity to make additional comments at the end of the interview. All of the comments made gave some indication of opportunities for improvement within the position and/or the company. These comments were tallied and grouped by common topics mentioned. The end result showed 6 distinct areas: 1) Human/Machine Interaction (including machine interface design, machine controls, and ease of use); 2) Plant Layout; 3) Process Improvement; 4) Communication with Management and/or Departments; 5) Workload/Need for Additional Workers; and 6) Additional Training and Support from Management. The number of comments for each is shown in Table 3.

Table 3. Number of additional comments by topic

Topic	No. of Comments
Human/machine interaction	30
Plant layout	13
Process improvement	17
Communication	15
Workload/additional workers	17
Training and support	9

Additional analysis was run to see if there was a correlation between Question 6, Levels of Automation, and Numbers of Tasks. No statistical significance was found.

5. Discussion and conclusions

So far discussion has formulated around a larger picture or macro-environment of possible solutions to a global issue. This study was an observation from the micro-environment of 28 different manufacturing facilities. It seems workers are comfortable with automation as long as it works properly. They are more likely to become frustrated with their work environment when machines have downtime or less than user friendly interfaces. The results of the study did align with previous research in the indication that if workers feel like they are stakeholders in the decision making process and daily success of the company, then they are more intrinsically motivated to meet the company's goals. From this study, the majority of workers did not feel they had the opportunity to advance in their current positions. After Human/Machine Interaction, Process Improvement and Workload were the most important factors in improving their work environment. Communication within the company across departments and employment levels was also important. After reviewing the literature, prior research pointed to training and support as a high priority in workforce development. This study backs training and support, but it was a lower priority factor to existing workers. With only 8% of the positions workers held being new to the companies within the last two years, the question arises as to whether companies truly are changing their products and processes thereby becoming agile manufacturers. With 65% of workers reporting automation being a positive factor in reducing their workload, it seems that workers are indeed ready for and even welcome new technologies. The question then remains, how should workforce development evolve to meet current demands? Thompson, McGraw, and Hair (2015) called for a probe into other indications besides the skills gap for possible reasons why workforce demands are not being met. With the focus on the current workforce, this study supports the idea of the three gap phenomenon: the skills

gap, the incentives gap, and the interest gap. When considering the answers to the eight questions on satisfaction and engagement asked in the interview, there is support indicative of an incentives gap. Employers must be willing to invest in their workforce. There is still room for further research into the interest gap which is not a focus here, but still has major importance especially with the average age of workers in this study being approximately 44 years of age. Taking all parts of the gap phenomenon into consideration is key. Implementation and reporting of this analysis should also be promoted throughout regions that are struggling with long-term unemployment. Solutions will lie in the appropriate education that encompasses human resource development as it relates to human information processing and information analysis. Job profiling is extremely important for companies, educators, and other workforce development agencies. The job profile allows each stakeholder to fully comprehend the exact skill workers need for a position. A valid job profile leaves no question about the skills required. Training can be tailored to fit and thus, reduce the seeming skills gap. As more modern approaches to manufacturing occur, companies need to make sure they are fully implementing quality management practices that do not take away from their workforce. Companies have to work together in their regions to develop an agile minded labor pool with the applicable soft skills required in agile manufacturing. For workforce development efforts to be successful, all parties have to come together to beat the gaps.

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Development of a Technology Readiness Assessment Process: A Case Study

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Abstract

Technology development is the process of developing and demonstrating new or unproven technology. It requires technology assessment at all stages of development to minimize wastages of time and money. Technology assessment level is an analytical activity. Its purpose is to provide decision makers where the development of a technology stands. Technology Readiness level (TRL) is a scale for measuring technology maturity. It was first introduced in the United States and followed by number of European countries. This study presents the development of the process that is used in assessing the technology development at the main national laboratory of Saudi Arabia.

1. Literature review

The development of TRL beyond its current nine levels (see Table 1) and into a more dynamic metric for assessing technology has been a part of numerous international agencies such as NASA, USA DoD and DoE, and several European countries. Much of the early work in this area was in defining the risks and costs associated with various TRL levels. These studies helped to expand the definition of respective TRLs, but still did not address the issues related to the integration of technologies or the progression through the TRL scale. The first study that attempted to expand TRL to consider an index and methodology for maturity difficulty through the TRL scale was done by Mankins (2002). He proposed an integrated technology index (ITI) that was a discipline-neutral, quantitative measure of the relative technological challenge inherent in various candidate/competing advanced systems concepts. The methodology, Integrated Technology Analysis Methodology (ITAM), then included a consistent hierarchy of subsystems and technologies across competing systems; identification of a TRL, Delta-TRL, R&D Degree of Difficulty; and a Technology Need Value; and synthesis of technology metrics across technologies and subsystems to determine an ITI. This then allows a comparative ranking of systems based on their ITI.

Table 1: Technology Readiness Levels

TRL	Definition
9	Actual System Proven Through Successful Mission Operations
8	Actual System Completed and Qualified Through Test and Demonstration
7	System Prototype Demonstration in Relevant Environment
6	System/Subsystem Model or Prototype Demonstration in Relevant Environment
5	Component and/or Breadboard Validation in Relevant Environment
4	Component and/or Breadboard Validation in Laboratory Environment

3	Analytical and Experimental Critical Function and/or Characteristic Proof-of-Concept
2	Technology Concept and/or Application Formulated
1	Basic Principals Observed and Reported

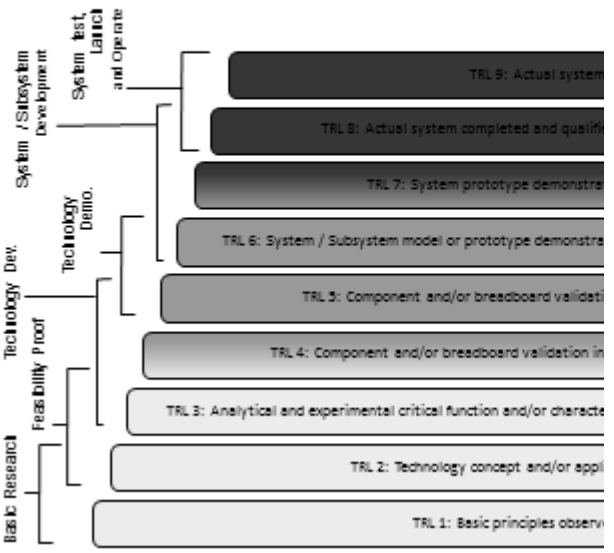
Meystel et al. (2003) brought attention to the issue of integration in their white paper on performance measures for intelligent systems by presenting detailed definitions of the nine TRLs and discussing the uncertainty and complexity of TRL integration, but did not present an integration solution. Shenhar et al. (2005) showed how TRL could be correlated to project risk and technological uncertainty for developing a project management framework, but only presented a static solution. Likewise, Valerdi and Kohl (2004) gave further attention to the impact that the maturity of a technology can have on system success when adopting the technology into a system. In response to some of these risks identified with technology maturity and the DoDs desire to take some of the ambiguity out of TRL, a research team with the Air Force Research Laboratory (AFRL) developed a dynamic TRL calculator (Nolte, et al. 2004). Using a Microsoft Excel spreadsheet application, a user can answer a standard set of questions about the developmental state of a technology and receive a graphical display not only of the technologies TRL, but how the technology rates above and below the scored TRL. It provides the user with a repeatable system for measuring a technology's maturity, snap shot of program maturity at a given time, and historical picture of what has been done thus far. Aside from Mankind's earlier work, there have been three other independent efforts to expand or enhance the TRL metric. First, the DoD introduced the concept of manufacturing readiness levels (MRL) to expand TRL to incorporate producibility concerns related to risks associated with time and manufacturing. MRLs are a metric that assesses the system engineering/design process and maturity of a technology's associated manufacturing processes to enable rapid, affordable transition to acquisition programs. The MRL index is used early in the development phase for acquisition program managers to comply with the DoD 5000.1 mandates (Cundiff 2003). Second has been the work of Smith (2005) at Carnegie Mellon Software Engineering Institute who expanded TRL to include additional readiness attributes of requirements satisfaction, environmental fidelity, criticality, product availability, and product maturity to define an evaluation framework of similar technologies. The third and most extensive developments have been by the United Kingdom's Ministry of Defense (MOD). Based on concerns for successful insertion of technology into a system, they have developed a Technology Insertion Metric that includes TRL, a Systems [Integration] Readiness Level, and Integration Maturity Level (Dowling and Pardoe 2005). They have then correlated systems engineering practices for each index based on phases in the systems engineering process and MOD Policy.

2. Why a Systems Readiness Level

Figure 1. represent the development process of technology readiness level 1 through level 9. While the efforts previously described have greatly expanded and enhanced our understanding of TRL, it is our premise that TRL is not an end state to determining a system's readiness based on:

1. TRL is only a measure of an individual technology and not systems readiness;
2. There is no method for integrating TRLs; and
3. There is no proven, tested, systematic index of systems readiness.

Figure 1: The development process of technology level 1 through



In theory, technology and systems development follow similar evolution (or maturation) paths, and technology is inserted into a system based on its maturity, and ability to integrate into the intended system. Some have described TRL as not only a measure of a technology maturity, but also a measure of its integration readiness, but we contend that two TRL 9s, technology mature, can be a different levels of integration maturity.

System Readiness Level (SRL) Index

The System Readiness Level (SRL) index is an index of maturity applied at the system-level concept with the objective of correlating this indexing to appropriate systems engineering management principals. The contend that the SRL of a given system is a function of individual TRLs and the maturities of the links between them, which will be defined based on a scale of integration readiness levels (IRLs). To understand this SRL dynamic, first endeavored to understand the relationship between TRL and IRL and how they are used to transform qualitative descriptions into quantitative maturity levels. In the following sections is description of the theory and development of the TRL, IRL, and SRL indices, the methodology is used to understand the dynamic relationships, and how to continue to validate and mature the SRL model.

Technology Readiness Level (TRL)

The key observation with regard to the TRL scale is that it only evaluates the maturity of an individual technology. As can be observed by the various descriptions depicted in Table 1, TRL takes a given technology from basic principles to concept evaluation through to 'breadboard' validation, then to prototype demonstration, and finally to completion and successful mission operations. While these characterizations are very useful in technology development they say nothing about how this technology integrates within a complete system. It is our contention that most complex systems fail at the integration points.

Integration Readiness Level (IRL)

IRL is defined as a systematic measurement of the interfacing of compatible interactions for various technologies and the consistent comparison of the maturity between integration points (TRLs). Using IRL to describe the integration maturity of a developing technology with another technology, developing or mature. The addition of IRLs not only provides a check to where the technology is on an integration readiness scale, but also a direction for improving integration with other technologies. As TRL has been used to assess the risk associated with developing technologies, IRL is designed to assess the risk of integration.

3. Research center understudy

Currently the research under study is in early phases of implementation of TRL. Therefore, no results are available of success and failure. Failure is not an end but should be an eye opener. Management should provide strong support to TRL development. Instead

this study proposes serval ideas in order to successful for introducing new technologies, they are:

1. **Selection of Technology and Priorities**

a. Identification of technologies which are (or may be) of importance to the country.
b. Selection of technologies that should be supported by the organization.
c. Acquisition and assimilation of selected technologies.
d. Exploitation of technologies to generate profit, or other benefits.

2. **Training of Scientists and Researchers on innovation skills.** It is apparent that scientists and research staff are lacking training on innovation. This must be a priority to all levels of management.

3. **Identifying the Critical Technology Elements (CTEs).** Scientists must not lose sight of technology priorities that stated on the science and technology plan. It could be clearly seen that scientists or the manager of each project is looking for his/her interests and nothing else.

4. **Assessing the Technology Readiness Level (TRL) and creating a check list that must be achieved for each TRL.** The TRL scale used as a pilot demonstration program for conducting Technology Readiness Assessments. Other programs, in developing their own program guides/manuals, should consider lessons learned from NASA and DoD experience in measuring technology readiness, as applicable and appropriate to their specific projects and programs. TRL indicates the maturity level of a given technology, as defined in Table 1 primarily for hardware items. Testing should be done in the proper environment and the technology tested should be of an appropriate scale and fidelity. Table 2 represent requirements that must be achieve in order to keep funding TRL at each level.

Table 2. check list & requirements for each TRL

Relative Level of Technology Development	Technology Readiness Level	TRL Definition	Description
System Operations	**TRL 9**	**Actual system operated over the full range of expected mission conditions.**	**The technology is in its final form and operated under the full range of operating mission conditions. Examples include using the actual system with the full range of wastes in hot operations**
FINAL System Commissioning	**TRL 8**	**Actual system completed and qualified through**	**The technology has been proven to work in its final form**

		test and demonstration	**and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental testing and evaluation of the system with actual waste. Supporting information includes operational procedures that are virtually complete.**
Early System Commissioning	**TRL 7**	**Full-scale, similar (prototypical) system demonstrated in relevant environment**	**This represents a major step up from TRL 6, requiring demonstration of an actual system prototype in a relevant environment. Examples include testing full-scale prototype in the field with a range of simulants in cold commissioning. Supporting information**
			includes results from the full-scale testing and analysis of the differences between the test environment, and analysis of what the experimental results mean for the eventual operating system/environment. Final design is virtually complete.
Technology Demonstration	**TRL6**	**Engineering/pilot-scale, similar (prototypical) system validation in relevant environment**	**Engineering-scale models or prototypes are tested in a relevant environment. This represents a major step up in a technology's demonstrated readiness. Examples include testing an engineering scale prototypical system with a range of simulants.1 Supporting information includes results from the**

			engineering scale testing and analysis of the differences between the engineering scale, prototypical system/environment, and analysis of what the experimental results mean for the eventual operating system/environment. TRL 6 begins true engineering development of the technology as an operational system. The major difference between TRL 5 and 6 is the step up from laboratory scale to engineering scale and the determination of scaling factors that will enable design of the operating system. The prototype should be capable of performing all the functions that will be required of the operational system. The operating environment for the testing should closely represent the actual operating environment.
Technology Development	**TRL 5**	**Laboratory scale, similar system validation in relevant environment**	**The basic technological components are integrated so that the system configuration is similar to (matches) the final application in almost all respects. Examples include testing a high-fidelity, laboratory scale system in a simulated environment with a range of simulants1 and actual waste. Supporting information includes results from the laboratory scale testing, analysis of**

			the differences between the laboratory and eventual operating system/environment, and analysis of what the experimental results mean for the eventual operating system/environment. The major difference between TRL 4 and 5 is the increase in the fidelity of the system and environment to the actual application. The system tested is almost prototypical.
Technology Development	**TRL 4**	**Component and/or system validation in laboratory environment**	**The basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared with the eventual system. Examples include integration of ad hoc hardware in a laboratory and testing with a range of simulants and small scale tests on actual waste. Supporting information includes the results of the integrated experiments and estimates of how the experimental components and experimental test results differ from the expected system performance goals. TRL 4-6 represent the bridge from scientific research to engineering. TRL 4 is the first step in determining whether the individual components will work together as a system. The laboratory system will probably be a mix of on**

			hand equipment and a few special purpose components that may require special handling, calibration, or alignment to get them to function
Advance Research to Prove Feasibility	**TRL 3**	**Analytical and experimental critical function and/or characteristic proof of concept**	**Active research and development (R&D) is initiated. This includes analytical studies and laboratory-scale studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative tested with simulants.1 Supporting information includes results of laboratory tests performed to measure parameters of interest and comparison to analytical predictions for critical subsystems. At TRL 3 the work has moved beyond the paper phase to experimental work that verifies that the concept works as expected on simulants. Components of the technology are validated, but there is no attempt to integrate the components into a complete system. Modeling and simulation may be used to complement physical experiments. Number of patents have been studied and evaluated.**
Initial Research to Prove Feasibility	**TRL 2**	**Technology concept and/or application formulated**	**Once basic principles are observed, practical**

			applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are still limited to analytic studies. Supporting information includes publications or other references that outline the application being considered and that provide analysis to support the concept. The step up from TRL 1 to TRL 2 moves the ideas from pure to applied research. Most of the work is analytical or paper studies with the emphasis on understanding the science better. Experimental work is designed to corroborate the basic scientific observations made during TRL 1 work
Basic Technology Research	**TRL1**	**Basic principles observed and reported**	**This is the lowest level of technology readiness. Scientific research begins to be translated into applied R&D. Examples might include paper studies of a technology's basic properties or experimental work that consists mainly of observations of the physical world. Supporting Information includes published research or other references that identify the principles that underlie the technology.**

4. Future Direction

This work is only the binging of total technology readiness level management system. TRL Management evaluation system must take place immediately to insure successful results. In addition, this study plans to continue evaluating and monitoring the TRLs progress at this institute. Progress will be reported to the top management.

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Managing the Deficiencies of Operational Profile Testing

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Abstract

As the software industry continues to grow rapidly, the research into software quality strategies continues to expand. One such widely researched and accepted strategy includes the use of an Operational Profile to determine the main focus of testing. Implementing a test strategy that fits a company's quality goals and objectives can have a direct impact on development costs and time to market. This purpose of this research is to review some of the common testing strategies used to ensure software quality that use the operational profile. Examining the various testing strategies may reveal common themes and criteria for evaluating these strategies. Identifying strengths and weaknesses within the test strategies will give opportunities for further research and lead to better strategies in the future. Since software testing can consume up to half of the software development costs reducing the effort can have a direct impact on development costs. Improving the testing strategy by eliminating a limitation can improve quality and give development teams a competitive edge. This research will also provide a strategy for further research into ways to close the identified gaps.

1. Introduction

The Software Operational Profile is a quantitative characterization of how a system will be used. It is widely used as a software testing strategy. Software Operational Profile testing has several deficiencies; lack of criticality, large number of operations, no input space controls, increasing rapidly increasing operation breadth, ignoring infrequent operations, lack of a way to deal with indirect input variables, possible correlated occurrence probabilities, and intimate prior knowledge needed. In this paper, I will review the current literature, outline a research approach, discuss expected findings, lay out the next steps, and offer conclusions. There are many benefits from using the various reliability models and specifically those including a software operational profile to develop testing strategy that will be discussed.

2. Literature Review

Focusing first on research pertaining to test strategies, Musa in 1993 [1] developed the software operational profile, or SOP, to help software project managers and engineers save both time and money when implementing a software project by using the operational profile test strategy. There are a few challenges with the SOP in practice which are brought up in the original Musa paper such as inclusion of criticality, controlling the number of operations, reducing input space, increasing operation breadth, ignoring infrequent operations, indirect input variables and correlated occurrence

probabilities. Some of these have been tackled in other papers which we will discuss further below.

In Urem and Mikulić in 2010 [2] the authors do a case study to show the effectiveness of the software operational profile in a real life study with an Enterprise Resource Planning system. In this study the authors conclude by showing a reduction in testing time directly related to the use of SOP with no change to the reliability of the software. Another case study, Chen, Mathur, and Rego in 1994 [3], was performed that completed a sensitivity analysis on the probabilities assigned when doing an operational profile. This study showed that you must be careful when assigning probabilities to functionality because minor mistakes in the probability assignment can have a significant impact on product reliability. Wagner in 2008 [4] wrote about defect classification, concluding that none of the standards out there today are widely accepted and there is a need for a standard set of defect classes. This set of defect classes could help expand the SOP research, based on the addition of criticality. A fuzzy software operational profile, or FSOP is introduced in Kumar and Misra 2007 [5] where linguistic information alone can be used to build the operational profile. This allows a profile to be built with no quantitative data collected about software usage, therefore it can be done before a software project is started. The use of multiple experts to generate the initial FSOP needs to be explored as it is one way to make the profile more precise. The operational profile is again put to the test in Marinkovic et al. 2013 [6] where it is used to develop a test strategy for television set top boxes. In this study MaTeLo is used, an automated test tool which generates test cases based on an operational profile. The tool allows you to develop the operational profile by connecting functionality of the system with the functionality that needs testing. The tool will also allow the user to enter test results and it will return metrics about software reliability. Targeted testing using an operational profile is discussed further in a case study using satellite payload software in de Fátima Mattiello-Francisco 2006 [7]. An increase in testing efficiency was attributed solely to the targeted testing with the operational profile.

Several studies into the use of the software operational profile as a test strategy have yielded unexpected benefits. In a study by Chruscielski and Tian in 1997 [8] the operational profile was used to test a module of a Lockheed Martin aircraft system. The work conducted, not only helped reduce test time and confirm suspicions of the developers, but also had the tertiary effect of renewing the customer focus of the development team. Testing using the operational profile is sometimes subsidized by other testing methods to identify greater amounts of failures. In Yueh Chen, Kuo, and Liu in 2009 [9] it was shown that operational profile testing combined with uniform test distribution, commonly used in adaptive random testing, can eliminate the need for a second testing strategy to account for the SOP deficiencies. Another area where the operational profile was combined with a second method that created additional benefits is when it was again used with adaptive testing in Lv, Yin, and Cai in 2014 [10]. In this study they use a modified adaptive testing method by applying a gradient descent method to the adaptive testing. By doing this the authors were able to prove a superior reliability estimation, while making it computationally less complex than the original adaptive testing technique. Another study by Gayen and Misra in 2010 [11] was able to apply the operational profile with black box testing on COTS software with no code. In this method, you start with the desired outputs and work backwards to find the paths back to all possible inputs. Fragile point analysis was utilized to determine where the software was prone to failure. With just a software specification and an end product,

reliability can be determined confidently. Using the operational profile to help design an optimal testing and maintenance strategy is discussed in Rinsaka and Dohi in 2006 [12]. In this method, the project is broken down into 3 phases: testing, maintenance, and operation. The idea is to come up with the optimal amount of time the project remains in each of these phases. With help from the operational profile, the desired reliability can be determined to exit each phase and therefore, you can determine the time to reach the desired reliability. Boogerd and Moonen in 2006 [13] used execution likelihood analysis in design and implementation of unit testing. This is like applying the operational profile to a unit testing strategy. Similarly to the operational profile, the parts of the code that are most likely to be executed are prioritized in the development of unit tests. This method helps developers remove the most common bugs before the software even gets to functional testing.

Inclusion of criticality is one of the challenges faced when using the software operational profile. A second article on the FSOP by Kumar, Misra, and Goyal in 2008 [14] continues the research and adds confidence limits using a fuzzy α-cut method for different confidence limits. This article also discusses the idea of methods to adjust the operational profile for software that has critical components with infrequent utilization. AlShathry in 2014 [15] also discusses the lack of criticality in the SOP. Their approach considers normalized probabilities based on the risk of a defect as well as the true probability. Takagi, Furukawa, and Machida in 2013 [16] introduced decision table based operational profile or DTOP. This method still focuses on the most used parts, but not just from user inputs. It relies on supplemental testing of functions that interact with a component where failure is caught. This expands the testing into the lesser used functions and can lead to a better defined root cause. In Li and Wang in 2014 [17] the authors use a mixed testing method to account for the inclusion of criticality, based on their experience testing radar system simulation software. This method of testing was able to find a greater number of defects as compared to the traditional operational profile, but it also increased the number of tests run, basically increasing the input space, which is another challenge of the operational profile and therefore has this same problem itself. In Alam et al. in 1997 [18] the authors make use of experimental design to not just utilize the probabilities of occurrence, but also the criticality of a defect to determine the operational profile.

A discussion on a test acceleration method in Alam et al. in 1997 [18] is based on experimental design, to account for the extended testing time due to the addition of the criticality measure. This accelerated testing technique does not address the reduction of the input space directly, but it does deal with the consequences of having a larger input. In Ai, Pei, and Yan in 2014 [19] the idea of doing virtual testing to help reduce the input space is discussed. The idea is to use known failures from unit testing to estimate reliability based on the operational profile. This method saves a significant amount of time, but at the cost of a higher error rate. If the product being tested does not have a high reliability requirement, this method would be a sufficient estimate. Another method to reduce the input space is developing the operational profile with a uniform design introduced in Fu and Min in 2009 [20]. This method is good for projects on a tight schedule that want to limit the amount of test time without sacrificing quality. An acceptable operational rating is determined and high level operations are used to create the operational profile and its probabilities. While still remaining under the desired operational rating, continue to break down the higher level processes with the highest probabilities. Repeat this until you are at or close to your acceptable

operational rating. This will get the coverage needed, while maintaining schedule and budget. Another challenge is addressed in Ao et al. in 2011 [21] where the authors discuss a scenario based approach which attempts to deal with the indirect input variables. This scenarios approach defines system level interactions which the traditional operational profile does not consider. This approach helps increase coverage by inclusion of indirect inputs, but also increases the size of the input space.

Increasing operational breadth is discussed in Lei, Bai, and Su in 2010, [22] where they talk about ways to expand the operational profile for open systems. In this paper they discuss 3 types of open systems but only delve into an open ended system that adapts to customer needs over time, leaving the other 2 types open for further research. One of the key concepts in this approach is the partial probability space used because the authors claim it is impossible to define the entire probability space in an open system. Another discussion of breadth can be found in Voas in 2000 [23] where the author takes on the challenges of COTS (commercial off the shelf) product managers. These challenges include not having a well-defined group of users and dealing with several different patch versions of operating systems (OS). The author discusses expanding the definition of the operational picture to include external interfaces to help with the various OS versions. To combat the user categorization he suggests having a type of users group where you collect data from individuals that volunteer to "test" the product. One draw-back to this approach is that you are late in the development cycle because you must already have a stable version of the software to apply this method. Highly innovative products in the consumer market have larger input spaces than other software products. To deal with this Lu et al. in 2007 [24] study user types, use processes and environments to determine if they have an impact on unexpected user-product interactions that could lead to unexpected faults. It is determined that User types and use process have a significant effect on software interactions while the verdict is still out on environments. Using this data along with the operational profile will increase the likelihood of finding more faults.

This research has led me to pursue filling the gaps that still exist in the software operational profile today.

3. Research Methodology

Developing an operational profile consists of the following five steps developed by Musa in 1993 [1]:

1. Fid the customer profile
2. Establish the user profile
3. Define the system-mode profile
4. Determine the functional profile
5. Determine the operational profile itself

My methodology modifies one step and adds an additional step. Between developing the functional profile and determining the operational profile I have added a step to determine a severity value based on the well-known FMECA technique. After determining the severity I altered the last step to create the operational profile with normalized probabilities that take into account the severity measure. The final step in Figure 1 below is test selection. This has always been what the operational profile was all about, selecting the proper tests to identify the right defects before a software release. The only difference is that I am researching test selection strategies to ensure consistent or reduced testing time while improving the defect find rate.

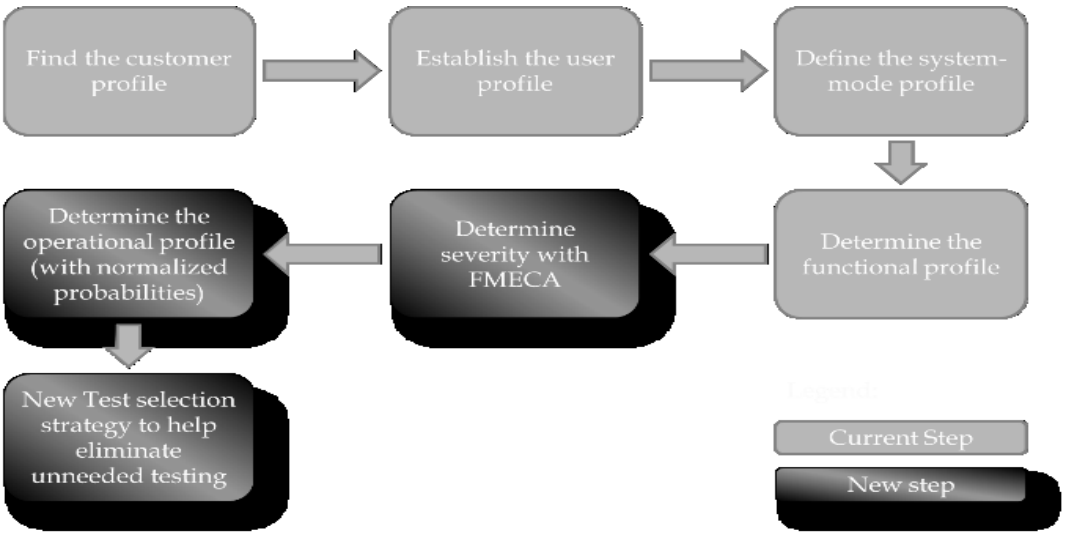

Figure 1. Research Methodology

4. Expected Findings

The addition of a severity measure and normalizing the probabilities with this severity will help testing find problems that may have been overlooked with traditional operational profile testing. The reduction of test cases with a new selection process will reduce the testing time and cost while maintaining a stable level of quality

5. Next Steps

Additional research into alternative methods of test selection is currently being conducted and should conclude soon. Research into test reduction methodologies will be the next topic researched. Finally research into automated testing to streamline the test process will be completed. Once these are complete I will perform a pilot study to prove my expected findings.

6. Conclusions

The Operational Profile is a proven effective test strategy. If we can close the gaps in the Operational Profile limitations we can control testing costs (up to half of development costs) and begin to balance test to development personnel ratios.

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Demand Forecasting and Production Scheduling for a Craft Brewery Company: A Case Study

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Abstract

Planning in an organization is a crucial practice to obtain success in any activity. In this context two methods related to the organization planning can be cited, the demand forecasting and the production scheduling. These two tools utilized together improve the marketing and production process, and consequently show great results for the company. The demand forecasting is an important practice in organizations due to its applicability for inventory management and decision making process. The main purpose of forecasting is to gain knowledge related to uncertain future events that are essential to any present decisions. Demand forecasting is an important tool between the marketing and production sector. Based on the demand forecasting, the production sector will define the quantity to be made in the process, while the marketing sector is always in contact with the customers, and this fact is important for the demand analysis and assumptions.

This paper presents the application of forecasting methods and the production scheduling to a brewery company in the USA. The company has produced seven kinds of beer empirically, without any prediction about the future demand and production scheduling. Facing this situation, the purpose of this study is to apply forecasting methods and a simulation model to predict the future demands, and based on these results, develop a production scheduling for the brewery company.

1. Introduction

A demand forecasting will never be perfect. Unfortunately, applying forecasting is a very difficult task, both in the short run and in the long run (Winston and Albright, 2001). Therefore, the fundamental goal for a forecasting is to have the smallest possible error, which is the difference between the real value and the forecast value. Consequently, it is important that managers and companies do not give up of the forecasting due to the far results from the real value of the demand. A system that improves continuously its forecasting can respond quickly to internal and external demands, through interdependence among production steps. It leads to reduction of lead time and high levels of inventory and avoid possible increasing of prices (Dias, 1993; Moon et al 1998).

Regarding the production planning, scheduling is related to organize the time and resources in an organization. Scheduling helps the decision making process and determines the processing sequence and how to use the organization resources, such as facilities, equipment, and human activity.

This paper presents the application of forecasting methods and the production scheduling to a brewery company in the USA. The company has produced seven kinds of beer empirically, without any prediction about the future demand and production scheduling. Facing this situation, the purpose of this

study is to apply forecasting methods and a simulation model to predict the future demands, and based on this result elaborate a production scheduling for the brewery company.

2. Background research

2.1. The brewery company

Craft beers represented $19.6 billion in sales across the country and 11% of all the beer volume in 2014 (Brewers Association, 2015). The case study company is a LLC brewery and it was started in 2013. Nowadays, this craft beer factory produces seven brands of beer, one flagship (continuous production) and six seasonal beers. The company has only one customer, a distributor, according to the Three-Tier System of alcohol distribution (e-Study Guide, 2012). In January of 2015, the brewery went through a shutdown, normalizing operations in March of the same year.

The brewery company also offers all Saturdays a tour open to the customers, where they can taste the beer brands in the tasting room. After July, the customer may take a growler home, 32 or 64 oz, in agreement with the new Bill 63 – 2015-2016 DB63 (Alcoholic Beverages, 2015).

2.2. Demand forecasting

The term demand means orders received in a defined geographic area, in a defined time period, in a business environment, and through a defined marketing program. This may be different from the sales, once customers can order products, which the company does not have at that moment (Eppen et al, 1991; Kotler, 1991).

Demand forecasts are assessments about the future that help managers by reducing some of the uncertainty, thereby enabling them to develop more meaningful plans (Stevenson, 1996). Forecasting is even more important for supply chains in which the information flow among suppliers is not well developed. The forecasting methods can be qualitative (subjective) and quantitative (objective). The qualitative forecasting methods involve the participation of experts and customers opinion. Some of known subjective methods are: sales force composites, customers' surveys, jury of executive opinion, and the Delphi method. On the other hand, the quantitative forecasting is made based on past history and analysis of data (Nahmias, 2009). The objective forecasting is also divided in two types: time series or extrapolation methods and regression or causal methods. Time series forecasting uses only the past history of the series to forecast, while regression models often incorporate the past history of more than one independent variable that influences the response variable (Eppen et al, 1991);Nahmias, 2009).

A consideration to be made when dealing with demand forecasting methods is to analyze if the series are stationary, or have some trend or seasonality. The methods for forecasting stationary series include moving averages and exponential smoothing. For series with trend, linear regression and double exponential smoothing via Holt's method are used. The method indicated for forecasting seasonal series is the Winter's method.

Thus, for short term forecasting is recommended to use times series, for medium term forecasting is a good practice to apply causal models and multiple regression, and for long term forecasting the Delphi method or scenarios analyses is indicated. Other long term methods require a long history data to be made, and this fact makes the forecasting more sophisticated. The methods used in those situations are known as economic forecasting and time series analysis. Examples are the Monte Carlo simulation and Box-Jenkins methodology.

To evaluate the demand forecasting method, a metric used is called forecasting error. The forecasting error in any period is the difference between the forecast for period "t" and the actual value of the series realized for the same period (Nahmis, 2009).

$$e_t = F_t - D_t \quad (1)$$

where:e_t = forecast error in period t;F_t = forecast value for period t; andD_t = actual demand for period t. Three types of forecasting error analyses can be cited in this context: MAD (average of the absolute errors over n periods), MSE (the average of the sum of the squared errors over n periods), and MAPE (the average of the percentage errors over n periods). The equations for each one of these errors are shown below:

Mean absolute deviation (MAD):

$$MAD = \left(\frac{1}{n}\right)\sum_{i=1}^{n}|e_i| \quad (2)$$

Mean squared error (MSE):

$$MSE = \left(\frac{1}{n}\right)\sum_{i=1}^{n} e_i^2 \quad (3)$$

Mean absolute percentage error (MAPE):

$$MAPE = \left[\left(\frac{1}{n}\right)\sum_{i=1}^{n}\left|\frac{e_i}{D_i}\right|\right] * 100 \quad (4)$$

The demand forecasting method chosen as the best will depend of the type of error selected as the criteria. According to Nahmias (2009), MAD (2) and MSE (3) are most utilized methods to measure the forecast accuracy. It is also necessary to monitor the forecasting errors to ensure that the forecast is performing adequately (Stevenson, 1996; Nahmis, 2009).

In this present study, six different time series methods were used (Moving Average, Exponential Smoothing, Regression Analysis, Trigg's and Leach'sAdaptive Smoothing, Ng's Adaptive Smoothing, and Holt's Method) with the intention of allowing the brewery company to be prepared to lead with its only distributor. The time series methods were chosen to provide a short term forecast (Chopra and Meindl, 2003). According to the M2 Competition of statistical forecasting methods, complex methods do not necessarily outperform simple methods (Makridakis et al, 1993). Hence, time series methods were chosen due to their simplicity and applicability in this case study.

The details regarding Moving Average and Exponential Smoothing methods can be found inDias (1993) and Winston (2001). Holt's two-parameter exponential smoothing model, or simply Holt's Method, extends simple exponential smoothing to include a linear-trend component and this method is explained in detailby Chiang (2005).

The Adaptive Smoothing Methods have the ability to adapt to a changing mean of an otherwise stationary and non-seasonal time series, by adapting the smoothing constant. This approach suppresses the problem of finding the better constant and has provided good results relating to other smoothing methods (Chiang, 2005; Ng, 2008).The smoothing constant varies at each time period based on the flow of the forecasting errors to make the model to react faster to sudden changes in the level or a shift in the demand pattern (Hoshyar and Sulaiman, 2014).

The Linear Regression Analysis is perhaps the oldest method of forecasting future demands and it is also actually simple. The least-squares method is used to seek "a" and "b", parameters of a line equation that represents the behavior of the demand over the time. After that, the equation can be used to forecast a future data (Thomopoulos, 1980).At each new data arrival, the methods must be recalculated with the newest one to get a new forecast.

2.3. Simulation modeling

According to Hoshyar and Sulaiman (2014), simulation models are utilized as a manner of determining systems behavior without implementing itself, since it is very costly and time consuming, allowing the investigation through tests and evaluations of proposals without the risk of actual implementation. In this context, a simulation language is defined as a software package that can address general applications and the model is developed by "programming". Law and McComas (1997) affirm that modeling flexibility and ease of use are the two most common criteria to select simulation software. Arena simulation software was chosen to conduct this research.

2.4. Production scheduling

Naturally, the final product of a company is processed at one or more work centers. Therefore, it is necessary at some point that the company defines a plan for carrying out a procedure. According to Nahmias (2009), scheduling is an important aspect of operations control in both manufacturing and service industries. It is the process of arranging, controlling and optimizing the work and workloads in a production process. Companies use forward scheduling to allocate machinery and plant resources, plan human resources and production processes.

Scheduling can avoid bottlenecks, minimize the makeup time and maximize the utilization time of the work center, reducing the resource idle time. The schedule technique is chosen based on how the process is defined. In this context, the process can be defined in relation to its flow and by the number of workstations. The flow divides the processes in two types: line low process (or flow shop) that is continuous; and divergent flow process, also called job shop. The scenario in the brewery is composed of a flow shop with three workstations, and the schedule technique closer to this kind of situation is the Johnson's rule (Operations Scheduling, 2015). Gantt chart was used to map the production schedule in this paper. Gantt chart is a popular type of chart that is essentially a time line of when activities start and finish.

3. Methodology

3.1. Demand forecasting

Based on the brewery company's demand issue regarding the distributor, it has been decided to develop the demand forecasting and production scheduling. The company has two challenges related to the production planning and distribution. The distributor just communicates his total sales per month, and it does not send the information about the weekly sales. On the other hand, Georgia's law enforces local breweries to have only one distributor as the means of selling their beer, and it does not permit breweries to change their distributor when looking for better performance of their supply chain.

The company gave the demand for its flagship brand data relating to the months of August of 2014 to April of 2015. Those data were computed on the Microsoft Excel and the results were analyzed. Figure 1 shows the demand behavior for the studied period.

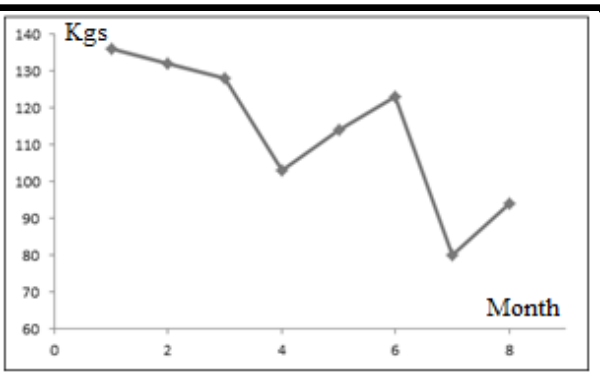

Figure 1. Brewery Company's demand

According to the initial results, the conclusions about the demand behavior were made, and the next step is to search the forecasting methods that fit to the company's flagship demand. Based on the search, the demand forecasting methods utilized were: Moving Average, Exponential Smoothing, Linear Regression, Holt's Method, Trigg's and Leach's adaptive smoothing, and Ng's adaptive smoothing.

3.2. Simulation modeling

To determine the demand for the tasting room, it must be considered the customers' preferences, and also the quantity for the "to go" option. Based on this need, a customer's opinion survey was conducted by the researchers on the tours offered by the company. The results of the survey were computed and used on the simulation model, which was made using the Arena Software.

As the goal is estimate the future demand, the model's performance measures are the volume per brand consumed in the tour. When the study was conducted, 5 tickets of 6 fl oz. per costumer and 4 different beer brands defined the consumption of beer in the tour. The company was interested in launching a new product that is a 32 or 64 fl oz. growler in July what could transform significantly the consumption within the tour. The model's flow diagram is presented in the Figure 2.

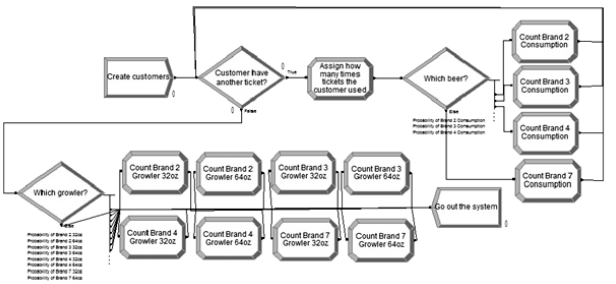

Figure 2. Brewery company's tour flow diagram

The model assumes that the same behavior of tickets distribution and preferences exhibited in the survey will happen in the future with some variation that can be tested inside the model.

According to Law and McComas (1997), to make model's results statistically precise it is important to define the length of each simulation run, the number of independent simulation runs and the length of the warm-up period. In this study, the simulation runs for 1-day tour specified in the number of people that show up. The number of independent simulation runs is 100 and there is not warm-up period since the model has its steady behavior from the beginning.

The number of people who attend the tour, the tickets' and growlers' probability distributions are control parameters as they are independent variables that affect performance measurements results.

To see how the manipulation of controlled parameters affects the performance measurements two experiments were conducted. First, number of people who attend the tour varied while fixing probability distributions. Second, probability distributions varied while keeping number of people constant. Process Analyzer software was used to have a better understanding of these experiments' results.

3.3. Production scheduling

The company has seven brands in its chart. These brands go through three work centers during the production process (Figure 3).

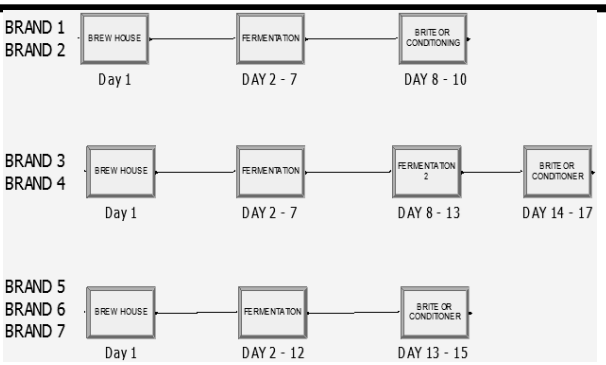

Figure 3. Work centers and related processing times for all the brands of the craft beer company

The company has one brew house and one conditioner, but three fermentation reactors available. The brands can be in three groups according to their sale method, as in Table 1.

Table 1. Groups of beer according to the sale method

Group	Brand
Flagship brand (on Market and testing room)	Brand 2
Seasonal On-Market (and testing room)	Brands 4, 5, and 6
Seasonal Off-Market (only testing room)	Brands 1, 3, and 7

Brand 2 is brewed throughout the year. The others are seasonal brands and they are not brewed all over the year. For the month of August, the brands 1, 2, 6 and 7 will be produced.

For the production scheduling the Johnson's rule for two work centers was used. This method allows the best production scheduling related to the processing time in work centers. The processing time for each job (brand) is presented in Table 2. There are three fermentation reactors in the brewery.

Table 2. Processing time for the 4 brands to be produced in August

Processing Time (Days)			
Job	**Brew House**	**Fermentation**	**Conditioner**
Brand 1	1	6	3
Brand 2	1	6	3
Brand 6	1	11	3
Brand 7	1	11	3

The following steps were made according to the Johnson's rule and Table 2:

- The four brands to be produced in August have three work centers: the brew house, the fermentation reactors and the conditioning tank. Since all the times for the brew house are the same (1 day), this work center was not considered in the Johnson's rule.

- The lesser times determine the position for the jobs production. In the case, the only difference was in the first work center time. The lesser times imply that two brands (here named brand 1 and brand 2) must be produced before the other two brands (brand 3 and brand 4).

After applying the Johnson's rule in the remaining workstation, a Gantt chart is the next step for the scheduling process. First, the demands in kegs for the four brands were found, according to the following steps:

- The demand for brand 2, the flagship one, was obtained by the linear regression forecast;
- The demand for brand 6 was found assuming that the behavior of the sales of this brand last year (related to brand 2) will be the same in 2015. The ratio between the sales of the brands 2 and 6 was calculated and applied with the forecast for the brand 2 to find the demand of brand 6 this year;
- The brands 1 and 7 got a result for the tasting room demand based on the simulation. Even though the simulation does not have data for the brand 1, it has data for the same group brands. Therefore, the data collected for brand 3 will be used as the brand 1 demand.

Knowing the demands of each brand, it was possible to know the number of necessary batches to serve the demands. According to the company's owner, each batch produces 58 kegs.

After that, a Gantt chart was made for the month of August following the order obtained by the restrictions below:

- The stock of the company for all four brands is zero;
- The Johnson's rule;
- The number of necessary batches;
- At least one batch of each brand needs to be done before the first day of August.

The last condition was chosen because all the brands need to be ready for the tasting room on the Saturday, August 1, 2015.

The factory does not work over the weekends. However, the fermentation process will continue during the weekend. This can be seen in the Gantt chart.

4. Results and discussions

4.1. Demand forecasting

The MAD, MSE, and MAPE values obtained using demand forecasting methods Moving Average, Exponential Smoothing, Trigg's and Leach's Adaptive Smoothing, Ng's Adaptive Smoothing, and Linear Regression are shown in Table 3.

Table 3. Initial results of demand forecast

	MA (4)	ES	TLAS	Ng's AS	LR
MAD (Kgs)	15.63	12.78	13.96	17.07	10.86
MSE $(Kgs)^2$	404.91	406.83	284.16	527.21	172.02
MAPE (%)	17.61	14.85	14.72	18.92	10.98

MA = Moving Average; ES = Exponential Smoothing; TLAS= Trigg's and Leach's Adaptive Smoothing; Ng's AS= Ng's Adaptive Smoothing; LR = Linear Regression

Based on the least vales of MAD, MSE, and MAPE, the Linear Regression model was chosen for the forecast of future demands. Figure 4 shows the regression and demand points.

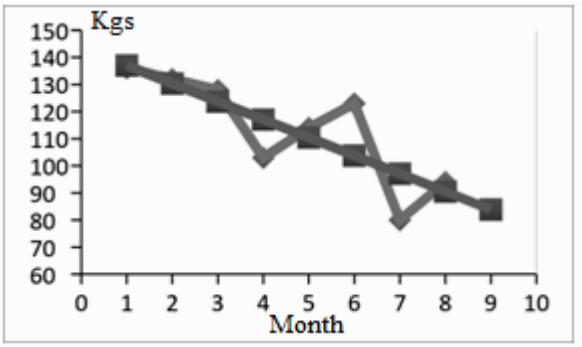

Figure 4. Regression Analysis

A possible concern that comes with this analysis is that, further forecasts using this method point to a future decrease in sales. If this happens constantly, it will cause serious profitability problems.

4.2. Survey

Before doing a simulation, a survey was taken in order to get feedback from the customers and to collect data to simulate the quantity for future production for market and "tours". The survey was conducted during 3 Saturdays in which 99 people contributed with their opinion.

Overall, the survey's results show the preferred beer brand on the tour, the beer brand that the customers want to take home through the "to go"

option, the customers' opinion about the tour, and the growler size that they prefer to take home.

4.3. Simulation modeling

Figure 5 shows the number of kegs per brand that is consumed in a 100 people tour. This figure presents the 95% confidence interval based on 100 replications of the experiment. This number of people was chosen because the observation points to numbers from 50 to 150. It is observable that 5 kegs are enough to address the demand to the most successful brand. In this case 100 replications were enough to narrow down performance measurements' standard deviation to a good range.

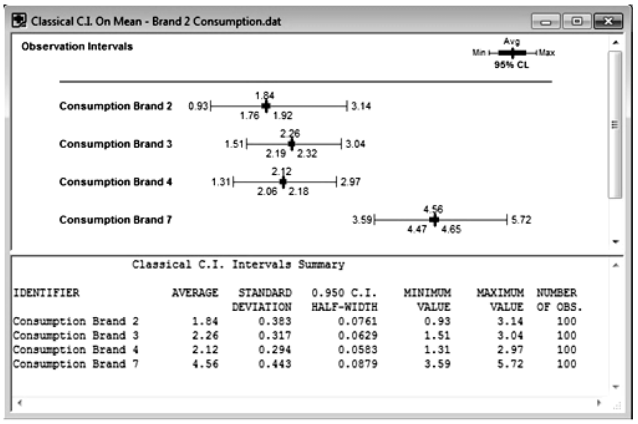

Figure 5. Brands' consumptions per tour

To analyze model's behavior when number of people changes, Process Analyzer was used. Different scenarios were created inside this software ranging from 50 to 200 with intervals of 10 people generating 16 scenarios. Observing Process Analyzer results the hypothesis that the demands to different number of people were proportionally emerged. To test this hypothesis Process Analyzer's results were transferred to Excel, plotted and calculated the R^2 (coefficient of determination) value of the brand's demands and the number of people; the R^2values were between 0.9998 and 1. Therefore, there is a great correlation between these variables. Figure 6 shows the chart constructed in Excel.

The final suggestion of production based on simulation analysis is presented in Table 4. It is the sum result of the biggest demand scenario to each brand when the probability of tickets changes and the maximum difference between the demand when growlers' probability changes, and the demand without any change in probabilities that is 0.89.

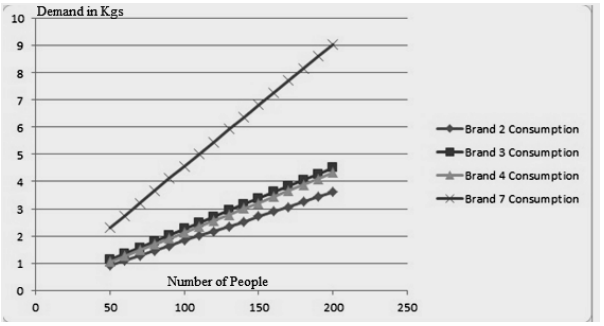

Figure 6. Number of people Vs. demand in kegs

Table 4. Final suggestion based on simulation analysis

Brand 2	$2.303 + 0.89 = \lceil 3.193 \rceil = 4$
Brand 3	$2.709 + 0.89 = \lceil 3.599 \rceil = 4$
Brand 4	$2.571 + 0.89 = \lceil 3.461 \rceil = 4$
Brand 7	$5.009 + 0.89 = \lceil 5.899 \rceil = 6$

4.4. Production scheduling

The production schedule was obtained by the Johnson's rule, the Gantt chart, the expected demand and the case reality conditions.

Table 5 provides the demands found for the brands, according to different methods. Observe that the historical data from August of 2014 was used only for finding percent ratio and not as a future demand. Only the brands 2 and 6 have a historical data provided by the distributor as they are the only brands on the market last August.

Table 5. Expected demand for August in kegs

Brand	Historical	Forecast	%Ratio	Simulation	Total
1				20.0	20.0
2	136	84		20.0	104.0
6	93		57.4	20.0	77.4
7				30.0	30.0

All the numbers in Table 5 are rounded results, except the brand 6 demand that was let as a decimal number to keep the proportionality of the historical data. The linear regression forecast was useful to get a demand for Brand 2 as 84 kegs of beer for the month. The demand for the Brand 6 was found by:

$$D_6 = [93/136]*84 = 57.4$$

In the simulation column (Table 5), a prediction for the consumption of the four brands was made in

the tasting room on Saturday. The simulation provided data for the brands 2, 3, 4 and 7. Although the brands 1 and 6 are not approached in these calculations, it is expected that they have the same behavior as the brands 3 and 4 respectively, once they are in the same group of sale method. Since the month will have five Saturdays, the results of the simulation were multiplied by five and transformed in kegs measure units. Thus, the expected demands for the consumptions in the tasting room and by the distributor were added.

The capacity of production is 58 kegs by batch, that is, by job processed. Hence, for the brands 1, 2, 6 and 7, respectively, the number of required batches is: 1, 2, 2 and 1. Stock for the four brands is expected for the month of September, once the total number of kegs that will be produced exceeds the required production.

Once all the brands must have a batch before the first day of August, the proposed sequence for the Gantt chart is: 1, 2, 6, 7, 2, 6. The Brewery can supply the batches demanded without the need to finish all batches before the month starts. The Gantt chart is presented in the Figure 7. The brands are differentiated by color: 1 in purple, 2 in yellow, 6 in green and 7 in dark gold.

	JULY																							AUGUST									
DM	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10
DW	F	S	S	M	T	W	Th	F	S	S	M	T	W	Th	F	S	S	M	T	W	Th	F	S	S	M	T	W	Th	F	S	S	M
CD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
BH	1			2	6			7							2			6														
F1		1	1	1	1	1	1		7	7	7	7	7	7	7	7	7	7	7													
F2						6	6	6	6	6	6	6	6	6	6			6	6	6	6	6	6	6	6	6	6	6	6			
F3					2	2	2	2	2	2	+					+	2	2	2	2	2	2										
CO								1	1	1		2	2	2			6	6	6	7	7	7	2	2	2					6	6	6

DM: Days of the Month (of July and August); DW: Days of the Week; CD: Consecutive Days; and the work centers:BH: Brew House; F1, F2 and F3: Fermentation Reactors; CO: Conditioner.

Figure 7. Gantt chart of the production for August 2015

From the Gantt chart, it's possible to arrive at some conclusions:

- To attend the demand, the production process takes 32 days if there is no stock;
- For having all the brands produced by the 1st of August, the process must begin on July, 10th;
- The limiting stage for the production path is the "Conditioner" work center.

Nonetheless, an analysis of possible backlog was made. According to the distributor historic data, the demand can be divided over the weeks. Then the weekly demand for the brands 1, 2, 6 and 7 would be 2.86, 23.27, 2.69, 5.58 kegs, respectively. The last day of the production schedule ends up on 10th of August, before the completion of the second week. Hence, all the supplies for the month will be done before the first keg is finished for all the brands.

5. Conclusions and recommendations

The main purpose of this paper was to explore, analysis and evaluate the application of the most utilized forecasting methods using a local craft brewery historical data, and based on the obtained results, to elaborate a production scheduling for this company. For the demand data analyzed, the results showed that, for this new craft brewery, the ideal forecasting model for the flagship brand is linear regression because it presents less error than the other methods. However, the historical data provided by the company was not enough to make a thorough analysis of the forecasting methods, since the company has been only two years in the market. The forecasting results will be different when more demand data become available since seasonality, cycles, and other factors will be observed in the demand data. It complicates to come up accurately with the best forecasting model. Whether the company's demand follows the obtained linear regression, it is necessary to take some actions to increase this demand.

The forecasting process gives a prediction for several uncertain future events and allows an estimation of the amount of error that can be anticipated in the forecast. Some events cannot be predicted by all forecasting methods, such as a shutdown, departure of a partner or shortage of raw materials. However, it is important to every company to have this kind of study because it helps to thrive on being prepared and tells the future environment in which the companies may operate.

The survey was essential to build the simulation model and production scheduling because it is important to understand the necessities from the viewpoint of the customer. The amount of 99 people was good enough to the purpose of the research, but for the future studies it would be more interesting and practical if the company makes the survey data available online, because the customers will feel more comfortable to respond by themselves.

The simulation was useful in estimating the future

demand of the brands in the tours. Especially if the system's behavior observed varies in the future, simulation will provide the final number of kegs to be produced of each brand to attend the tour.

Regarding to the production scheduling, Johnson's rule was used to create the Gantt chart for the four brands that will be produced in August 2015. The method was able to meet the expected demand in 32 days of process, without risk of backlog and loss of the distributor order.

For future studies, it is recommended to test the forecast methods again and try other methods, based on more historical data, in order to improve the forecasting system. With more information gathered it is also possible to tune better the simulation model so that the need to stock can diminish. For accurate scheduling, a Material Requirements Planning (MRP), utilizing the production scheduling methods, would be useful when there are stocks available for the brands.

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A Framework for Assessing Social Network Interactions in Interdisciplinary Research Projects

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Abstract

Interdisciplinary research (IDR) addresses research problems that are beyond the scope of a single discipline. Interactions and social relations among IDR participants impact the success of such projects, with research showing that IDR may fail due to lack of interactions between research members. Therefore, a generic framework for assessing and evaluating the social network of IDR projects is needed. The framework consists of tools such as surveys, personal interviews, and focus groups, with each being conducted at various stages over the course of an IDR project. Data on frequency of interaction between IDR members, connectors, members at the core/periphery of the network, discipline, gender, etc., should be collected over the study period. After collecting the data, qualitative and quantitative analyses are required to evaluate the IDR. As a case study, 14 IDR projects at Binghamton University that included undergraduates in all STEM disciplines were studied, each consisting of faculty and graduate mentors as well as undergraduate students. The objective was to study the social relations between undergraduate students and their faculty and graduate mentors using the proposed framework. The framework not only helped map the interactions and relations between all team members, but was also used to evaluate the success of each project.

Keywords*: Interdisciplinary research (IDR), social network analysis (SNA), assessment framework.*

1. Introduction

The need for collaboration in science is well recognized. Scholars have become gradually aware of interdisciplinary research (IDR) as a scientific conceptual model that links or integrates a wide range of disciplines through incorporated theoretical frameworks to answer critical questions, or to simplify problems in a specific area [1]. For example, the reduction in the current rate of tobacco usage was not only associated with the discovery that tobacco is a leading cause of lung disease, but also by all the additional research on motivation, risk, economics, and all the other factors that contribute to designing tobacco assessment programs [1]. Therefore, IDR as a collaboration between scientists working with mathematicians, physical scientists, computer scientists, engineers, and many other disciplines are now able to ask and answer more complex questions than at any other time in the past.

New forms of social interaction have been established between IDR scholars. Social structures have emerged from IDR interactions, in addition to the outcomes of the research collaboration. Social network analysis (SNA) aims to map relationships between people, organizations, groups, etc., to provide visual and mathematical analysis of related interactions. The word "network" captures the relations between interactions in the form of actors (people/organizations/groups) linked by edges/relations/ties to comprise a social structure. The "network" is then interpreted to focus attention on relationships and attributes among network actors. SNA differs from social science research in that it reveals detailed individual responses to the problem under study rather than providing all data in a statistical format.

The BU-HHMI program (a program funded by the Howard Hughes Medical Institute at Binghamton University) is a biologically-related interdisciplinary (IDR) student research program for undergraduates in all STEM disciplines. The program attempts to encourage more students from underrepresented minority (URM) groups to enter fields related to science, technology, engineering, and mathematics (STEM) upon graduation. In the present study, 14 IDR projects were approved to participate in the program. The participants in the 14 IDR projects consist of faculty mentors, graduate mentors, and undergraduate students. Faculty and graduate students in each project are from the disciplines involved and serve as mentors to undergraduate students. Interactions between each group and all other groups started with participants' attending training workshops which allow them to be aware of processes and issues that are relevant to IDR. Workshops aimed to establish a common vocabulary and framework for interaction, reflection, and discussion between groups. SNA will be employed to determine best practices that lead to success in IDR for undergraduates, and its effectiveness in recruiting students in STEM fields into biologically-related, research-based careers.

Over a period of three years, SNA in IDR projects in BU will be studied. Therefore, having a robust and reliable framework is essential. Considering the several interaction structures that may take place in such a group of projects, mixed evaluation methods are needed to help collect data for analyzing social networks. Surveys/questionnaires, personal interviews, and focus groups are some of the well-known methods for collecting relevant information and discovering links between people's interactions. Integration of the aforementioned methods will result in a deeper understanding of participants' interactions and relationships. Additionally, the data collection methods need to be well designed in order to meet study requirements.

Frequencies of interactions among participants, connectors, discipline, and gender are examples of relevant data to be collected. After the data are collected, qualitative and quantitative analyses will be used to evaluate IDR.

The primary objective of this research is to propose a generic framework for studying SNA among IDR groups in order to evaluate research

outcomes. In this framework, we will propose a comprehensive data collection and analysis methodology for evaluating IDR from an SNA perspective. Social networks can be used to evaluate interdisciplinary collaborations by analyzing relational data within the area under study. With the framework as a guide, a data collection plan is proposed with three data collection methodologies: surveys, personal interviews, and focus groups. This study also proposes an order for implementing data collection methodology along with the evaluation phases. The next section of this paper reviews relevant literature for this study. Section 3 below sets forth and illustrates the proposed assessment framework, while section 4 discusses the current work in implementing the proposed framework to evaluate BU interdisciplinary research groups. Section 5 concludes the study with a discussion of further work required to validate this assessment framework.

2. Review of Relevant Literature

Interdisciplinary research is gradually becoming obligatory for research organizations as a condition for funding. These funding opportunities have encouraged the collaboration between different disciplines to conduct IDR. Collaboration between disciplines used to take the form of multidisciplinary research (MDR), where researchers from different disciplines worked independently on problems. In contrast, interdisciplinary research requires researchers from different disciplines to work jointly and retain their research in the form of comprehensive work [7]. Benefits of collaborations between disciplines include improvement of problem-solving with an enhanced solution quality and development of a new landscape in science, where changes are made in the intensity, formality, elements and extent of collaboration [7, 9]. Moreover, IDR trains and educates next generation of scientists, engineers, and researchers to collaborate and interact in their disciplines and with other disciplines to integrate the research of the future [10].

Interdisciplinary research education programs help to increase awareness among undergraduate students from different majors of other disciplines, especially in STEM fields. They also increase the enrollment of undergraduate majors in IDR fields, in addition to enhancing non-majors' understanding of science and engineering [11]. Studies have shown that IDR is challenging. Barriers between researchers can limit the success of IDR projects. Some of these challenges are terminological barriers, communication barriers, finding an intellectual community to support IDR, cross-disciplinary knowledge mastery, and integrating conflicting methodologies [12]. Accommodating such challenges in conducting IDR needs a deep understanding of three categories: individual bridges and barriers, disciplinary bridges and barriers and programmatic bridges and barriers [13]. Avoiding such problems can be achieved by the following: establishing a strategy for accountability between researchers, developing formal and informal communication strategies, selecting team members thoughtfully and strategically, recognizing and respecting timing issues, defining focal themes and research questions jointly and clearly, emphasizing problem definition and team proposal writing, targeting interdisciplinary training, and identifying mentors who can focus on team integration issues [12].

3. The Social Network

Social network analysis is a promising approach for evaluating IDR [7]. Social network analysis can be used to answer questions about the performance of networks and how they grow and interact over time. SNA considers IDR as a network of collaborations between individuals and can be used to measure these collaborations and evaluate team performance. Some of the questions that can be addressed by applying SNA to IDR are as follows: Are all group members connected, or there is a formation of subgroups in the network? Is there a central individual who

connects the network together? What patterns of team assembly are formed within the network? Answering these questions and many more that can result from SNA will provide an evaluation of the IDR and help to improve it [7]. There is a growing field of literature on applying SNA to the evaluation of group research.

Pereira and Soares (2007) conducted SNA to improve the quality of the requirements of systems that support information management in an R&D institute, "An interface institution between the academic world and business world of industry and services" [13]. In their study, they describe the technique they follow to collect data for building networks. Some of the requirements for collecting the data were to gather, manage, and distribute information about the study in the organization, and to obtain an up-to-date information system for all employees and management to provide group communication and facilitate collaboration between employees and management. Conducting an SNA showed that showed that only 10.8% of the relationships in the network were being used in an effective manner and the communication between individuals could occur more efficiently.

4. Interactions Assessment Framework

The assessment framework proposed in this section tries to fill the need for a generic procedure to evaluate IDR using interactions among participants by analyzing their social networks. Providing a detailed framework of all phases of assessment will allow users to customize the framework to fit any evaluation of social networking among study participants. This framework will be validated throughout the duration of the research. To address all data requirements for evaluating IDR using SNA, a mixed evaluation method was integrated to form an interaction assessment framework, as illustrated in Figure 1. This framework is adapted from [2]. It uses several methods to collect data over the research timeframe, and then the data are analyzed and used to evaluate the research groups. This section will focus on explaining each element in the framework.

4.1. Observations

In order to build a general overview about research participants, observations are the first step of the assessment protocol. Depending on the nature of the research, observations can take place in weekly meetings, special meeting events, workshops, etc.

By observing participants, researchers will begin building a general idea about the relationship dynamics between individuals and groups. In addition, observations will build a bridge of confidence between the researchers who conducting the study and the study participants. This will have an impact on later activities in data collection methods such as personal interviews and focus groups. Observations can take place throughout the study period without being limited by the assessment phase or timeline. Moreover, in the analysis phase, observation will make more contributions to the qualitative analysis part of the evaluation phase.

4.2. Surveys

Surveys or questionnaires are powerful tools for capturing individual responses and opinions in a particular case. Surveys can be done several times in the study timeframe. Pre and post surveys are also possible outside of the research timeframe in order to capture responses before and after the study was conducted. Surveys questions can vary based on study requirements. In this framework, three surveys are proposed. The first survey will be designed to identify any previous relationships between study participants. This will help in the analysis phase by evaluating projects where there were previous relationships and interactions between participants and comparing that to another group with no previous interactions and analyzing the results. A second survey is recommended halfway through the study period. The best time to conduct this survey will depend on specific milestones that can be previously determined. At the end of the study, a final survey will be very helpful in determining the final set of interactions between study participants. It is very important for all the individuals who are involved to participate in the surveys in order to get relevant data and avoid making any evaluations based on missing data at various points of time.

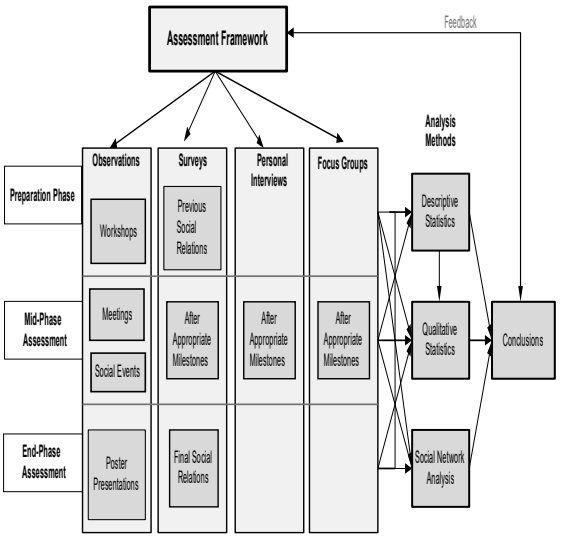

Figure 1: Interactions assessment framework

4.3. Personal interviews

Although surveys are powerful tools to capture individual opinions in a particular study, in some cases it is difficult to identify a specific point by relying only on surveys. Personal interviews will solve such a problem. Detailed answers to questions can be obtained by conducting personal interviews. It is appropriate to ask questions that need additional explanations or more elaboration in a personal interview. Yes/no questions, on the other hand, are not to be asked in interviews. Interviews should be conducted in a convenient place for all participants. A time schedule for all interviews is to be defined and all participants should be notified and reminded of the day and time their interviews will take place. All interviews should be conducted within a specified timeframe and should be as close to each other as possible in order to have an accurate result that represents the same period of time for all participants. Audio recording is recommended to record the interview discussion for future analysis.

4.4. Focus groups

Focus groups sessions are other tools employed to gain insight into participants' points of view, in particular, of specific issues. Focus groups are held with a group of volunteers (who are

interrelated to the focus group subject) to discuss a particular issue within the study interests at appropriate milestones.

Throughout the study period, at any time, focus groups can be conducted. The number of participants in focus groups can vary based on the issue under study, but it is preferable not to exceed 12 individuals. The length of the focus group sessions is also a factor of the complexity of the issue under discussion, although it is not recommended to exceed 90 minutes for each session. Recording the discussion is very important for the analysis phase after completing all sessions. [3] The focus group location should be predetermined and given to all participants along with the session date and time. The location should be neutral in nature; for example, if a focus group session is to address a health issue, the session should not be held in a healthcare facility. Each focus group session should be facilitated by a moderator. A moderator is a person who has the ability to provide a relaxed and nonjudgmental environment during the session. The moderator should be a good listener and is unbiased in relation to any of the discussion trends; the moderator should also share some of the participants' characteristics, such as age, sex, or language. The moderator is usually accompanied by a note-taker who is responsible for capturing the emotional aspect of the discussion.

4.5. Quantitative and qualitative analysis

The quantitative analysis takes place after collecting the data from previous methodologies. The analysis consists of facts, demographic information, possible challenging points, etc. The quantitative analysis is performed by applying simple statistical analysis. The analyzed data are then used as inputs to the qualitative data and for the evaluation phase. The quantitative analysis will then be developed to emphasize the important points to be considered in the evaluation.

4.6. SNA

SNA is conducted to evaluate the study sample according to the social interactions among participants. Studying social networking, where participants ("actors") are interconnected to each other by one or several relationships, will provide fundamental measurements that describe the nature of the interactions and the network properties. Incorporation of the SNA into the complete evaluation phase is accomplished by identifying a set of SNA measurements. SNA measures can vary based on the nature of the desired evaluation. Table 1 summarizes some well-known measures that result from analyzing social networks.

Table 1: Some SNA measures [4, 8]

Some Social Network Measures	
Measure	Definition
Size	Describes the number of network actors
Frequency	Describes how often a link exists between two actors
Multiplicity	Describes whether two actors are linked to each other by more than one relation
Direction	Describes the direction of links between two actors
Symmetry	Describes a bi-directional relation between two actors
Degree	Describes the number of direct links between actors in the
In-degree	Describes the number of incoming links to the actor from other
Out-degree	Describes the number of outgoing links from the actor to other
Closeness centrality	Extent to which a node is central to a network, giving a number of ties count for a node
Betweenness centrality	Extent to which a node mediates between any other two nodes
Centrality	Extent to which a node is central to a network, giving a number of ties count for a node
Density	Describes the ratio of the number of actual links to the number of possible links in the network and indicates connection potential in network
Isolate	Describes an actor that has no links to other actors

5. Current Work

In the present study, the network actors are the 14 projects members of the BU-HHMI program. The types of relationships between actors were investigated by collecting information which ranged from basic, such as whether or not actors had ever heard of or met each other before, to detailed, such as the strength of those interactions Moreover, relationships between participants were categorized as professional or social. Other relationships were also collected, such as interactions between undergraduate students (UGs) and faculty mentors (FMs), UGs and graduate mentors (GMs), and between GMs and FMs. Collecting data on relationships started with observing the initial formation of the projects, the introductory workshops, and the first breakfast meeting. Three surveys are to be conducted for collecting data throughout the study period (one academic year).

The first survey was conducted one week after the teams started working. The questions for survey 1 were designed to collect statistical and demographic data from participants, in addition to capturing any previous relationships between them. The second survey was conducted in the middle of the summer, where all groups had to work for eight consecutive weeks on their projects; the survey was designed to capture in detail the interactions between individuals and groups, both socially and professionally. Survey 3 will be discussed in the next section.

To collect more information about projects and interactions, personal interviews took place at week 6 of the summer in order to include every individual participating in the programs. The interviews were scheduled a week beforehand, and all participants were reminded of their interview dates. The questions were the same for all participants with a few modifications based on the occupation of the person. For example, if the individual was a UG student, the questions were focused more on the barriers to working on IDR and the effectiveness and frequency of interactions with team members, etc. On the other hand, if the interviewed individual was an FM or GM, then the questions were more focused on the performance of the UGs and to what extent they were involved in the work, as well as the amount of collaboration between the two disciplines. The interviews were then transcribed and categorized into themes. Themes and common answers were then found in the results for each group. Conclusions and explanations for specific statistics were then drawn from the results. Because the HHMI grant seeks to encourage students from URMs to pursue their education in research-based careers, three focus groups sessions were held during the last week of the summer. Those focus groups aimed at providing the assessment team with the students' points of view on being URMs and how that affected and will affect their choices in the past and the future. A control group was conducted to capture majority students' points of view about the URMs in STEM fields. Transcriptions of all interviews were completed, and then thorough analyses of the results were discussed by the assessment team. Themes and conclusions were extracted from the analysis and a model of prominent components and interactions was developed. In this model, all the themes were categorized and elements of each theme were underlined. Connections and relationships between the general themes, elements of different themes, or general themes and elements were emphasized in the model.

To evaluate the IDR projects, SNA was performed based on the data collected. Data for SNA were developed from coding surveys and interviews results. Interview responses were coded in the manner discussed in [5]. The coding methodology was adapted from [4, 8] and summarized in Table 2. After coding was completed, relationship matrices were built to describe interactions. Each matrix represents a particular relationship between participants. For example, one matrix was developed to model the professional relationship between UGs and FMs, another matrix presented the social relationships between UGs, and so on. USINET software was then used to build social

networks. Each matrix used to model a single network and perform several SNA measures such as centrality, density, and betweenness.

6. Conclusion and Future Research

This study has proposed a framework of mixed evaluation methods for evaluating IDR projects. In the study, 14 groups are to be evaluated based on their interactions. The mixed evaluation methods proposed to collect data required for evaluation are observations, interviews, surveys, and focus groups. SNA is to be performed on relations network between projects' participants to evaluate teams. This research is an ongoing study for a three-year period of time beginning in 2011. The proposed framework is to be further investigated and enhanced over the period of the study. A comprehensive compression between the three years of research is to be performed to test the framework and incorporate each year's feedback to enhance the evaluation. This paper discusses the pilot year of the study, which was more conceptual in nature.

Table 2: Coding steps for interview responses

Steps	Description
Define coding categories	Must be all-inclusive and exhaustive, Pretested by posing different questions (e.g., for males and females in a gender-based survey)
Assign code labels to the category	Each category has a unique code used to summarize and condense information
Classify relevant information into categories	Relevant information must be extracted from transcripts
Test reliability of coding	Using test-retest method and independent coder
Measure Reliability of coding	Using percentage agreement method by checking percentage match between independent
Locate source of unreliability in coding	Used to increase the reliability of coding; main causes are interviewers' fault, coders' negligence
Review and implement codes	Reviewed until desired reliability is obtained and codes are

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Using Process Engineering to Improve Workflow and Office Organization

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Abstract

Over the years, lean and other industrial engineering tools, such as discrete-event simulation (DES), have been adopted to organize office space, streamline processes, and improve overall workflow. In the present study, these tools were implemented in the International Student and Scholar Services (ISSS) office at Binghamton University (BU). Although the number of international students/scholars has significantly increased over the years, this office operates in a limited space. Therefore, industrial engineering tools were used to help address two major issues at the ISSS: file/workflow and front desk organization. Since the office staff are located in two separate buildings that are not connected, the movement of paper files and documents associated with those files, as well as file tracking, can be problematic and time-consuming. Moreover, the front desk staff operates in a limited workspace, which affects the workflow and the organization of work in processing files and documents, thereby increasing students' waiting time in queue for service. Using lean concepts, the proposed process redesign was tested using DES to quantify the impact of a new office layout on student waiting time and file flow cycle time. Simulation results indicated a reduction in students' waiting time and file flow.

Keywords: Process engineering, lean, value stream mapping, 5s, simulation.

1. Introduction

In the past few years, the number of international students in United States universities has increased significantly. The enthusiasm for new learning experiences, new research opportunities, the availability of applications via e-forms, and a welcoming environment in U.S. universities are a few factors that have contributed to this increase. In order to welcome and serve international students, universities have stand-alone departments which are responsible for all issues related to international students. The prime focus of such departments is to facilitate compliance with the federal regulations that govern international students. In addition to that, these departments provide information, education, and services in support of these regulations to the international population in universities and in local communities. An efficient and streamlined workflow, accompanied by a welcoming environment, is necessary to achieve the mission of such departments.

The Office of International Student and Scholar Services (ISSS) at Binghamton University serves a population of more than 2100 international students and scholars with seven full-time employees, three part-time employees, and 18 graduate assistants and part-time student assistants. Their main purpose is to help international students with all sorts of questions and/or difficulties they may encounter in a completely new environment. The ISSS conducts orientations for new incoming international students to familiarize them with the university's rules and guidelines. These orientations are mainly focused on guiding the students through such activities as applying for Curriculum Practical Training (CPT), Optional Practical Training (OPT), obtaining a Letter of Invitation

(LOI), applying for social security numbers (SSN), dealing with academic difficulties, gaining an extension of stay, obtaining health insurance, etc. Hence, they have a major responsibility for guiding and helping the students in a variety of tasks.

As most departments/offices do, the ISSS office faces some challenges in the office operations which need to be addressed. At a June 2011 ISSS staff retreat, the staff identified managing workload, inadequate office space, and inefficient paper filing systems as among the office's top challenges. It was suggested at the staff retreat that outside expertise be sought to help address these challenges. At a follow-up staff meeting in July 2011, the ISSS staff brainstormed about the specific office operations that they felt were most in need of review and improvement and would most benefit from process engineering. These operations were file flow/workflow and front desk organization.

Process engineering has played an essential role in streamlining workflow and increasing work efficiency in services. Service providers need to integrate the mode of providing services effectively, taking into consideration the significance of cross-functional processes. As the service world changes to provide more flexible, timely, accurate, and efficient service, the value of process engineering is being recognized [1]. Additionally, process engineering redefines the skills of the staff involved, redesigns organizational structures, and streamlines workflow. It overcomes space and/or time limitations to optimize process performance and support the service providers in making their decisions in a timely and effective manner [2]. Many engineering tools and concepts are involved in process engineering, such as lean concepts, modeling and simulation, quality control, and many more.

The primary objective of the present study was to streamline file flow and workflow and to identify opportunities for improvements in the organization of the front desk to utilize space more efficiently. This would help in increasing the efficiency and effectiveness of the services provided in the office in addition to increasing the satisfaction of students and of ISSS staff. Furthermore, applying process engineering in the ISSS office result in a reduction of the file cycle time and students' waiting time in queues. Two main areas within the ISSS office were studied, namely, (i) file flow/workflow and (ii) front desk organization. In this study, lean principles, simulation, actual to standard office space comparison, and layout redesign were the tools used to identify opportunities for improvements and to develop recommendations for both challenges. By testing the changes in layout redesign using simulation, this study provides validation support for the proposed layout suggestions, which are unique to office layout organization. Previous research has validated layout design using traditional geometry calculations. [3, 4]

2. Review of Relevant Literature

Process engineering involves the rethinking and fundamental redesigning of any process to achieve and sustain improvements in cost, service quality, flexibility, and innovation [10]. By providing the opportunity to study a process in its all stages, process engineering decreases the number of inefficient activities and focuses on streamlining workflow with the help of industrial engineering tools. Grossmann and Westerberg [11] have described process engineering as the understanding and development of processes, at unlimited levels, in order to design and enhance their performance in a way that promotes productivity, reproducibility, sustainability, and comfort by providing lean and durable solutions to the challenges which the processes raise.

The literature addresses the importance of lean principles as one tool of process engineering. How lean tools can be implemented to bridge the gap between various departments within the offices to improve its working environment is explained by Fabrizio and Tapping in the book, 5S for the office, [9] which illustrates in detail the 5S system and how it can be used to improve the organization of office desks. The

implementation of the 5S system standardizes the working environment for all staff members, since the same standard is maintained throughout the office.

Sturek et al. [5] used process mapping techniques to achieve higher efficiency through ergonomic rehabilitation of a registrar's office which did not meet the standards as specified by OSHA and NIOSH. Sturek et al. developed a design for a folder for applicants' files which was more ergonomic and easy to access. They made a detailed analysis of the recommendations and increased the efficiency of the office using ergonomics.

Keyte and Locher's book *The Complete Lean Enterprise* (2004) discusses the use of value stream mapping (VSM) in detail from the initial step of designing a value stream to the development of a future state. It gives an idea of the efficient use of VSM in different situations and helps in identifying waste. [7] Recently, Grewal described an initiative to begin using value stream mapping in a small company and described the effect of the lean tool VSM. VSM increases the efficiency of a process by eliminating waste. The process is studied and a VSM is developed for the current and future state. The proposed state (the lean state) is one where the process is carried out without any non-value-added activities in the process. This results in an overall increase in efficiency of the process. [8]

Wong described how Kansas University has established detailed standard guidelines to be followed in offices. In these, each step in planning for office space from the design process to the types of spaces and planning guides is standardized. The guidelines provide standards for the actual space required for the movement of staff members and the pieces of furniture and equipment used in the office. These minimum standards were useful because they allowed the present researcher to compare the existing space at the ISSS to the standards. [6]

The present study was based on the application of lean tools to overcome the difficulties faced by the ISSS and to standardize their process and make it more efficient. The potential impact of the recommendations on the workflow was simulated and monitored. The key performance measures considered were the waiting time of the students in the queue, the length of the queue, application processing time, and the utilization of resources. Additionally, this research effort is one of the very few attempts that have examined using industrial engineering tools to streamline the workflow in an office environment.

3. Methodology

The ISSS office has many work-in-progress files and papers at the front desk and the file flow between the offices was difficult to track.

The space constraints were a limitation which was contributing to the restricted movement of staff members and was also directly related to the cause of the major drawbacks. The researcher began this process engineering project by studying the dimensions of the relevant problems and defining all their related issues. Two problems were identified in detail, as follows:

3.1. File Flow/Workflow:

The ISSS staff is housed in two adjacent buildings that do not connect. The movement of paper files and documents associated with those files can be problematic when staff members in one building are seeking a file which has been removed from its normal storage location by staff members in the other building, or even when it is in a staff member's office on the same floor as the person looking for it. The ISSS office has Excel spreadsheets that serve as file locators, but the current system is inefficient, time-consuming, and interferes with good customer service.

3.2. Front Desk Organization

Space of all kinds is at a premium in the main office suite, and space for visitors is extremely limited. Another issue is how the front desk reception staff organizes their workflow, how they move paper and files from one location to

another, where they keep things that are only partially processed, and the system for tracking how documents flow from the point of intake to the point of mailing or pick-up. There is also a need to better organize the reception desks themselves to facilitate this process. These desks are staffed by a rotating team of paid student employees, so there is not a consistent staff presence at the desks.

To address these two issues, a detailed study of each problem was conducted. Voice of the process (VOP) and voice of the customer (VOC) data were collected to identify the process and the system requirements. Several lean tools such as the spaghetti diagram, 5S, a Supplier Input Process Output Customer chart (SIPOC), and value stream mapping (VSM) were developed to identify opportunities for improvements in the ISSS office. Office layout between the two floors was studied and a new layout was proposed. The proposed layout was tested using simulation to quantify the impact of changing the layout on the time spent by the students in queues and file flow.

ISSS office traffic data provided by the ISSS staff were first studied. The data contained the number of arrivals and reasons for students' visits for the past two years. From the data, it was clear that the number of students arriving at the beginnings of semesters was very high compared to the number of students in the middle of the semesters. Thus, the months April and May were identified from the data as the peak periods, and the number of students visiting during those months was approximately 1000 students. These data were used in the simulation model. Reasons for visits to the ISSS office were also collected and analyzed.

Figure 1 is a detailed flow chart of the activities which take place in the ISSS office starting from the customer's arrival and continuing to the point where the customer leaves after getting the required service. It is clear from Figure 1 that the customers (students) visit the ISSS office for five main reasons: to meet with a staff member (either as walk-ins or by appointment), to ask general questions, to request documents (such as letters of certification or letters of invitation), to pick up documents, and to drop off documents. Accordingly, the researcher focused on the major five classifications and aimed at improving them in order to make the organization more effective and increase student satisfaction by reducing the amount of wait time in the queue and enabling faster processing of documents. After the flowchart was developed, process mapping was implemented to study the current workflow (baseline) of services provided in the ISSS office and to identify the potential bottlenecks in those processes. The ISSS provides a variety of services and each one is unique in its own way. Therefore, the tools SIPOC and VSM were used for to map all services in order to understand the flow of files and reduce unnecessary movement. The present study offers a detailed analysis of one major service in the ISSS office. Extension of stay is a process that occurs in some cases when international students are required to complete their degree. It requires the advisor's recommendation for the student along with the student's GPA and other credits, including financial documentation. Figure 2 represents the current VSM of the extension of stay process in the ISSS office at BU. A detailed analysis of the process was developed and suggestions were made about how to reduce the amount of the non-value-added activities.

Meanwhile, the front desk organization problem was tackled by the implementation of lean tools and the recommendation of a new office layout. The front desk employees had to perform multi-tasking, such as answering phone calls, operating the computer, responding to emails, updating data, serving students, and so forth. Therefore, it was essential for them to work efficiently within the confines of the space available. Due to the physically limited space in the front desk area and in the ISSS office in general, lean tools were essential in helping to overcome this problem. 5S is a Japanese technique which stands for *seiri* (sort), *seiton* (straighten), *seiso* (shine), *seiketsu* (standardize), and *shitsuke* (sustain). This lean tool was applied to each of the front desks in order to increase their work efficiency. Front desk workspace, drawers,

cabinets, information cards, wires and cables, and unused documents are all examples of areas where 5s was implemented. As there are several workers working on a shift basis at the front desk, it is essential to establish and maintain standards so that the employees are more aware of the status of their work and related documents. Another area of focus in the front desk organization was studying the dimensions for various spaces and equipment in the office and comparing these to space and equipment standards. These space standards were assumed to be the minimum standard requirements according to the literature and needed to be satisfied to assure an efficient work environment. The dimensions for the equipment, aisles (primary and secondary), and workstations in the office were measured.

These dimensions were then compared to standards in order to identify whether they satisfied the requirements. To accomplish this, the entire layout of the office was drawn to scale, including the furniture and major equipment like a scanner, telephones, file cabinets, and so on. The entire layout of the ground floor of the office is shown in Figure 3. Several changes in the layout were proposed and tested using simulation to determine their impact on student waiting time.

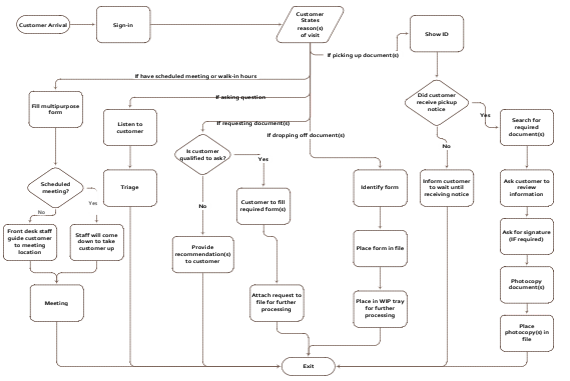

Figure 1: Flow chart of possible customers' actions in ISSS office

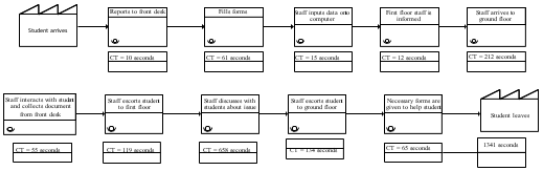

Figure 2: Current state value stream map of extension of stay process

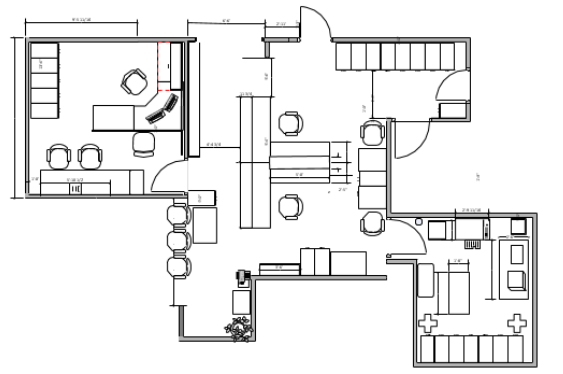

Figure 3: Ground floor layout of ISSS office

4. Analysis of Recommendations

The researcher conducted VSM on the subprocesses of the extension of stay process by studying the current state; then, after proposing some possible improvements, a future VSM was developed. The main objective was to be able to serve more students during their appointment or walk-in time. Initially, the sequence of events taking place was observed and recorded. The sequence of events for the extension of stay process was as follows:

- The extension application form records details about the student and also additional information required for processing.
- A front desk staff member uses information from a database to complete a portion of the application form;
- A staff member reviews the application, notifies the student of the financial documentation needed, and reviews the advisor's recommendation and the student's transcript;
- A staff member prepares a report for final review by the director of ISSS and then updates the file locator;
- The director decides whether to approve the application or not based on the recommendations.

From the sequence of events taking place, a SIPOC was created in order to understand the basic idea of the process. A detailed SIPOC is the first step to gain in-depth knowledge of the process being studied.

A current state VSM (Figure 2) was developed based on the SIPOC diagram to identify the value-added and non-value-added activities in the process. Each activity along with the average time taken is recorded and charted. Then the activities are classified as value-added and non-value-added from the student's perspective. The following table shows the value-added and the non-value-added activities in the process.

Table 1: Value-Added and Non-Value-Added Activities

Value-Added Activities	Non-Value-Added Activities
Discussion of issue with concerned	Reporting to front desk
Help from staff	First-floor staff coming to ground floor
	Escorting student to first floor
Total time: 10.96 minutes	**Total time: 11.39 minutes**

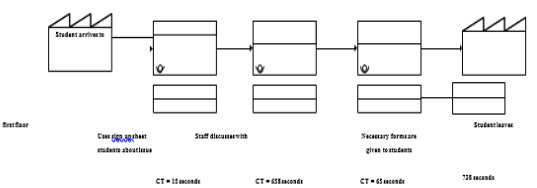

Figure 4: Proposed VSM for Extension of Stay Process

Due to the physical difference between the first floor and ground floor in the ISSS office, the process of getting assistance from first-floor staff requires more time and involves more non-value-added activities. The percentage of non-value-added activities is high compared to the value-added activities and this creates more opportunities for improvements. The proposed solution involves the students going to the first floor after reporting to the front desk without the assistance of the first-floor staff. The documents required by the staff are made available a day earlier, as the appointments are available for the next day only. Additionally, some of the forms which were placed in ground floor alone must also be kept on the first floor in order to improve efficiency. A proposed VSM for the process

was developed. The proposed VSM (Figure 4) eliminates most of the non-value-added activities and increases time efficiency by 45% and allows approximately 10 more students to be served per week.

For the desk organization problem, 5S was implemented at the front desk and in all offices in the ISSS. As a first step, all the items were sorted based on their frequency of usage into the categories less frequently used, frequently used, and not used. The items which were not used at all were removed from the front desk and the items which were frequently used were positioned on the table, making them easier for the front desk employees to access. As a next step, there was specific place assigned for telephones, fax machines, printers, and other small office supplies such as staplers. These were marked by small printed pictures of the objects so that they were easily identifiable. The procedures were standardized and the front desk employees were trained to follow the procedures so that they can sustain the improvement process. As a result of the 5S, the employees were more motivated to work due to a cleaner new working environment.

After addressing the desk organization problem, layout changes were made. The front desk consists of two employees. Just behind the front desk is the second-row worker stations whose workers update the files and perform other tasks. The door opposite to the front desk leads to the office of the SEVIS operation assistant and the door to the right leads to the office of the director. File cabinets which have files related to current former students are adjacent to the walls. The door next to the second-row workers consists of the photocopying machine, office supplies, and other items. As can be seen from the layout, the space is very congested to move around in.

The next step was to compare the actual layout with the standards so as to identify the scope for improvements. The comparison between the standard guidelines and the existing space in the ISSS office is shown in Table 2.

Table 2 shows that most of the space for personnel and equipment did not meet the standards. As result, there were congested queue formation, staff distractions, unnecessary wait time, restricted movement, increase in chances of error, etc. Addressing these space requirements was the most important factor in improving the efficiency of the processes being performed. It was not possible to increase the space without moving to a new office which had more space. But carefully applying some of the lean tools makes it possible to make changes in layout which facilitate space for movement and increase the efficiency of the process. To identify the area where more space needed to be created, a spaghetti diagram was drawn.

The observation from spaghetti diagram led to focusing on the secondary aisle between the front desk employees and the second-row workers. There was frequent movement of staff members along this aisle to the photocopying room and to other offices. This aisle was considered to be a bottleneck which caused a delay in providing services. Moreover, the primary aisle and the students welcoming area were also considered to be insufficient, resulting in lengthy queue formation. A new layout was proposed that involved shifting the second-row workers to the SEVIS assistant office, thereby creating more space for the secondary aisle movement. This would remove the bottleneck of the staff members and facilitate easy movement. At the same time, the layout also created more space for the primary aisle and thus a reduction in queue size. The equipment and other machines which were interfering with the primary layout were moved to an appropriate place, as shown in the proposed layout in Figure 5.

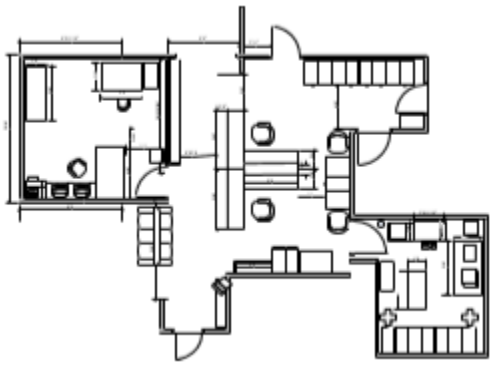

Figure 5: Proposed layout of ISSS Office

Table 2: Comparison between Actual Standards and Existing Space

No.	Area	Standard Guideline	Existing Space
1.	Primary Aisle	4 ft	< 3 ft
2.	Secondary Aisle	3 ft	2.5 ft
3.	Small Equipment (such as fax machine)	12 sq ft	2.4 sq ft
4.	Workstation	30 (5*6) sq ft	12 (3*4) sq ft
5.	Photocopier	72 sq ft	26 sq ft
6.	Space for Professional Staff	3 ft	2.3 ft

The single-sided chairs were replaced by double-sided chairs so that students can be accommodated for filling forms and waiting for their turn. In addition, the entrance is being slightly modified. The stand with pamphlets and plants are being replaced with a foldable desk which can be used for the purpose of filling out forms. When not in use, it can be folded towards the wall so that there is more space for the students to wait in the queue. Additionally, a flat-screen LCD monitor can be installed to make the operations more sophisticated by allowing students to sign in, fill out forms, and schedule appointments. This provides more space than the existing layout.

In order to evaluate the effectiveness of the proposed layout, it was essential to evaluate before implementing the process. Hence, a simulation model was developed to test the model's effectiveness. The baseline for the simulation model was the periods of peak arrival, which are April and May. Therefore, the model would mimic the system as it functioned in April and May. From the given and observed data, a check for normality was conducted.

For the month of April, the Anderson-Darling (AD) test of normality failed to reject the hypothesis of normality for arrival data at a significance level of 0.05. For the month of May, the Anderson-Darling (AD) test of normality rejected the hypothesis of normality for arrival data at a significance level of 0.05.

The data from peak periods were then tested to identify whether they could be combined to fit distributions. The Mann-Whitney test was used to identify the possibility of a combination. The Mann-Whitney Test is a test for assessing whether two independent samples come from the same distribution or not. The test failed to reject the hypothesis that the April and May arrival data came from the same distribution at a level of significance of 0.05. The calculated p-value was 0.1655. Thus, the April and May data were combined to fit the distributions for arrivals.

To build the simulation model, some assumptions were made. These assumptions were as follows:

- The April and May arrivals data were considered for developing the model;
- The front desk always has two employees for operation during office hours and in the absence of front desk employees the ISSS has staff members to cover it;
- The working hours of the ISSS office are from 10:00 a.m. to 4:30 p.m. on weekdays, except for Thursday, when the office opens

at 11:30 a.m. and closes at 4:30 p.m.;
- The system is considered to be a terminating system, as it starts and finishes with an empty office.
- The number of students served (1:00 – 3:00 pm), cycle time (CT) of student visit to the ISSS office, average waiting time in queue, and average number waiting in the queue were all output performance measures of the model.
- The number of replications was 100 and the length of each replication was 5 hours;
- The warm-up period was 3 hours (10:00 – 1:00 pm).

The simulation model was validated against the average number of students visiting the ISSS office at peak hours in May. The simulation model showed a decrease in student waiting time in the front desk area of 8.56%.

5. Conclusions:

Offices and service departments in most organizations are struggling with identifying methods to streamline their workflow in order to accommodate increased demands and work volume. The objective of the present study was to streamline the workflow and file flow and to organize the front desk at the International Student and Scholar Services (ISSS) office at BU to improve the usage of the limited workspace so as to meet the increasing demands of international students. Process engineering tools such as lean methods, 5s, and simulation were used to streamline the process. The focus of the study was on the file flow/workflow of students' files, and the organization of the front desk area. Additionally, a proposed new office layout design was developed to enhance and optimize the first floor space. The recommendations could be implemented at no cost and would achieve approximately 8.56% decrease in student waiting time according to a simulation model of the new layout. Moreover, the changes associated with the extension of stay process increased the process efficiency by 45% in addition to increasing the number of students seen each week by approximately 10. The abovementioned recommendations will help streamline the process in the ISSS office at BU and similar office environments elsewhere.

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