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Enhancement of Green Energy Manufacturing Engineering Education through Project Based Learning and Leadership Workshops

Prof. Tzu-Liang Bill Tseng, University of Texas, El Paso

Dr. Tseng is a Professor and Chair of Industrial, Manufacturing and Systems Engineering at UTEP. His research focuses on the computational intelligence, data mining, bio- informatics and advanced manufacturing. Dr. Tseng published in many refereed journals such as IEEE Transactions, IIE Transaction, Journal of Manufacturing Systems and others. He has been serving as a principle investigator of many research projects, funded by NSF, NASA, DoEd, KSEF and LMC. He is currently serving as an editor of Journal of Computer Standards & Interfaces.

Dr. Richard Chiou, Drexel University (Eng. & Eng. Tech.)
Dr. Radian G Belu, University of Alaska Anchorage

Dr. Radian Belu is Associate Professor within Electrical Engineering Department, University of Alaska Anchorage, USA. He is holding one PHD in power engineering and other one in physics. Before joining to University of Alaska Anchorage Dr. Belu hold faculty, research and industry positions at universities and research institutes in Romania, Canada and United States. He also worked for several years in industry as project manager, senior engineer and consultant. He has taught and developed undergraduate and graduate courses in power electronics, power systems, renewable energy, smart grids, control, electric machines, instrumentation, radar and remote sensing, numerical methods, space and atmosphere physics, and applied physics. His research interests included power system stability, control and protection, renewable energy system analysis, assessment and design, smart microgrids, power electronics and electric machines for non-conventional energy conversion, remote sensing, wave and turbulence, numerical modeling, electromagnetic compatibility and engineering education. During his career Dr. Belu published ten book chapters, several papers in referred journals and in conference proceedings in his areas of the research interests. He has also been PI or Co-PI for various research projects United States and abroad in power systems analysis and protection, load and energy demand forecasting, renewable energy, microgrids, wave and turbulence, radar and remote sensing, instrumentation, atmosphere physics, electromagnetic compatibility, and engineering education.

Mr. Oscar H. Salcedo, University of Texas, El Paso

Bachelors of Science in Mech Engineering, Master of Arts in Political Science, currently pursuing PhD degree in Engineering Education. Director of Corporate Relations for College of Engineering at the University of Texas at El Paso, and Coordinator for the Research Institute for Manufacturing and Engineering Systems.

Aditya Akundi, University of Texas at El Paso

Aditya Akundi is currently a doctoral student at the University of Texas at El Paso in the Electrical and Computer Engineering Department, Industrial and Systems Engineering (ISE) track. He earned a Master of Science in Electrical and Computer Engineering at the University of Texas at El Paso (UTEP) in 2012. He has worked on a number of projects in the field of Electrical & Computer Engineering, Systems Engineering, Additive Manufacturing and Green Energy Manufacturing. He is the current president of INCOSE UTEP student chapter along with being involved in UTEP Green Fund committee. His research interests are in Systems Engineering & Architecture, Complex systems, Systems testing and Application of Entropy to Complex Systems. Email: sakundi@miners.utep.edu

Dr. Eric D Smith, University of Texas, El Paso

Eric D. Smith is currently an Associate Professor at the University of Texas at El Paso (UTEP), a Minority Serving Institution (MSI) and a Hispanic Serving Institution (HSI), He works within the Industrial, Manufacturing and Systems Engineering (IMSE) Department, in particular with the Master of Science in Systems Engineering Program. He earned a B.S. in Physics in 1994, an M.S. in Systems Engineering

in 2003, and his Ph.D. in Systems and Industrial Engineering in 2006 from the University of Arizona in Tucson, AZ. His dissertation research lay at the interface of systems engineering, cognitive science, and multi-criteria decision making. He earned his J.D. from Northwestern California University School of Law.

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ABSTRACT

This paper describes enhancement of green energy and manufacturing subjects using a project based learning and leadership workshops as an educational strategy in a new manufacturing engineering program. There are a number of challenges facing green energy manufacturing from industrial perspective. For example, green energy manufacturing is a complex and technology-concentrated set of processes; therefore, it requires a very specialized and experienced workforce. In this paper, a LEGO® based project and various "Green Energy Manufacturing (GEM)" leadership workshops, which are used to enhance student's professional success, are introduced. Basically, a semester long GEM project using LEGO® and a few general and technical leadership workshops were arranged and delivered during the Industrial, Manufacturing and Systems Engineering (IMSE) Day. The paper is aimed at integrating green energy into the manufacturing engineering curriculum and to cultivate leaders in the field among minority and female engineering students. Successful completion of the course will lead to excellence in green energy and advanced engineering education.

Keywords: Project Based Learning, Leadership Workshop, Green Energy, Green Manufacturing, Engineering Education

INTRODUCTION & BACKGROUND

Green Energy today, is not only seen as a trend in industries but also as a tool to address many sustainability issues along with increased educational opportunities and having main stream impact in various manufacturing dimensions. Renewable energy, which is estimated to have provided around 19% of global energy consumption in 2012, has created a global investment trend by drawing in around 249.4 billion USD in 2013 [1]. With a rapid growth in United States clean energy economy, it is deemed vital for emerging young workforce to be knowledgeable and well trained in the field of green energy & sustainable manufacturing. To address this, United States department of labor (DOL) has provided approximately 2 billion USD in funding to community colleges to train emerging workforce in energy and manufacturing [2]. It is also to be noted that global investment in clean energy industries is expected to grow from 200 billion USD in 2010 to nearly 600 billion USD by 2020 [3].

Green Manufacturing as defined by Smith and Melnyk [4] is "a system that integrates product and process design issues with issues of manufacturing planning and control in such a manner as to identify, quantify, assess, and manage the flow of environmental waste with the goal of reducing and ultimately minimizing environmental impact while also trying to maximize resource efficiency". Increased environmental consciousness among manufacturing industries helped to foster new techniques for streamlining processes and increased reusability. Financial benefits, Global Image, Environmental conservation, Regulations compliance, Stakeholders, Green innovations, Supply Chain requirements, and Market trends are some of the drivers identified by Govindan *et al* at industries for adoption of green manufacturing technologies [5]. The current motivation of manufacturing organizations is to mainly comply with regulations, but, many

studies support that once green manufacturing is successfully implemented it reaps long term benefits of cost reduction, low energy consumption and improved processes.
Increased global adoption of green energy and green manufacturing technologies presents a reformation of engineering education geared toward renewable energy and green manufacturing practices. According to a research brief titled *"Investment in renewable energy generates jobs. Supply of skilled workforce needs to catch up"* from the digest *"Skills and Occupational needs in Renewable Energy* [6], it is estimated that by 2030 up to 12 million people could be employed in clean energy sectors. It is also mentioned that, there is a widespread skill shortage of engineers and technicians with knowledge in in the field of renewable energy technologies. Based upon the need for increased skills in renewable energy and green manufacturing technologies, this paper discusses a project based learning approach taken, along with a series of workshops held in the field of Green Energy Manufacturing to enhance student professional success at *XXXXXXXX*. In the following sections of this paper, a detailed explanation of the course objective, course content, LEGO® project used for project based learning as a part of green energy manufacturing class and green energy manufacturing workshop series are given.

GREEN ENERGY MANUFACTURING COURSE *(IE4395/IE5390/MFG5390)*

The inaugural class for the Green Energy Manufacturing (GEM) program was installed on the fall 2013 academic semester with 30 enrolled undergraduate and graduate students from various engineering programs in the college. The main objective of Green Energy Manufacturing class offered at *XXXXX* was to introduce students to fundamental concepts of green energy and environmentally conscious manufacturing. The course helped students to get acquainted with current energy and environmental decision issues that surround products and processes. Case studies were developed using GaBi™ Product Life Cycle Sustainability software based on life cycle analysis to increase student exposure in different life cycle stages along with life cycle decisions. To incorporate both green energy and green energy manufacturing, the class was divided into two different modules where, *Module I* was based on Green/Renewable energy and *Module II* incorporated life cycle analysis, concepts of green manufacturing and project based learning.

Module-I: The aim of this Module-1 was to provide basic concepts of Green/Renewable energy. This module incorporated various aspects associated with renewable energy such as *Green Electric Energy Systems, Wind Power Generation, Solar Energy, Solar Photovoltaic (PV) Output Power Forecasting.* At the end of the Module-1, the students were able to understand and analyze the renewable energy technologies and their impact on the power grids.

Module-II: The purpose of this module was to describe a problem towards a student project and to propose a model and/or solution approach for solving the identified problem using several green energy tools and GaBi™ software to create life cycle balances and to interpret and analyze the results of life style impact assessment in decision making. The concepts and examples presented included notions and ideas about: *Design Structured Matrix (DSM), Design for Assembly (DFA) vs. Design for Disassembly (DFD), Fundamental of Wind Turbine and Solar Panel, Failure Mode Effect Analysis (FMEA), Life Cycle Assessment (LCA) - GaBi™ version 5 Applications,* and *Learning DFD Concepts through LEGO® Wind Turbine Project*

The main highlight of the course was project based learning environment created as a semester long Green Energy manufacturing project based on LEGO® wind turbine. This semester long project incorporated both hands-on and software tools. The Software aspect of the project was to identify and develop Life Cycle Analysis based on LEGO® wind turbine manufacture. In order to assess the impact of a LEGO® wind turbine manufacture, the primary focus related to *"Raw Material Acquisition", "Material Processing", "Unit Assembly", "Product Use Phase", and "Disposal"*. Please see Appendix C for a Sample LEGO Wind Turbine Life Cycle Analysis Modell Developed using GaBi™ Software.

On the other hand, to increase student awareness on operational processes in green energy manufacturing, particularly in assembly and disassembly processes, students were divided into a team of four and have been assigned with a LEGO® Wind Turbine, which includes a renewable energy kit. The teams were tasked to exercise the assembly and disassembly process based on the concepts of modularity. It was observed that students generated different test cases with innovative solutions based on assembly and disassembly sequences and cycle times. The add-on renewable energy kit was used to collect wind power data generated by LEGO® wind turbine based on Wind Velocity, Linear distance, Angle and coordinates. (Note: Please see academics.utep.edu/gem for student project reports and results)

Figure 1: Experimental Setup for Optimal Wind Energy generation using Wind Velocity, Linear Distance, Angle and Co-ordinates.

Semester Project Evaluation: When students responded to their self-assessment about the skills gained about Life Cycle Assessment (LCA) and GaBi™ application concepts, eighty-five percent reported skills ranging from "Awareness" to "Application" skill levels by the conclusion of these concepts instruction. Responding about their skills gained at the end of the presentation about application of DFD concepts via LEGO® wind turbine, close to eighty-nine percent of the

students reported skills ranging from “Awareness” to “Application” levels and 11 percent indicating having reached the “Analysis” skill levels at the end of semester project.

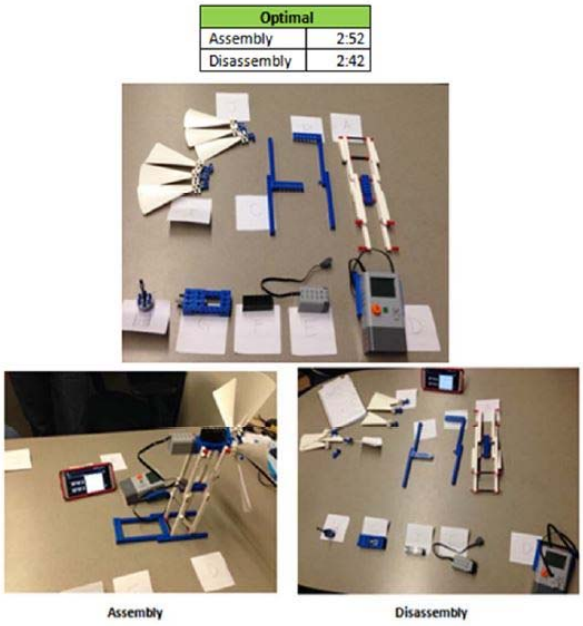

Figure 2: LEGO® Wind Turbine Assembly and Disassembly Process for Optimal Solution

TECHNICAL AND LEADERSHIP WORKSHOP SERIES

A series of technical and leadership workshops have been conducted to support and expose minority-engineering students towards cultivating their skills in emerging green energy manufacturing technologies. Workshops were organized and coordinated as a part of Sixth *Annual 2014 Industrial, Manufacturing, and Systems Engineering (IMSE) Day* held at the campus of the *XXXXXXXXXX* during the days of the 24th and 25th of April. The focus of the seminars was to continue with the offering a series of professional development sessions to address key issues currently debated and discussed in the Green Energy Manufacturing field. The majority of the planned workshops were directed to address important topics and problems related to green manufacturing education as well as the current leadership directions in preparing 21st century technology-savvy workforce and leaders. Six workshops were conducted, wherein, three were geared towards engineering ethics and technical leadership and the other three were based on Green Manufacturing and energy efficiency. The details of these workshops are given below.

Workshop – 1
Title: Development of Agent Based Simulation for Building Systems
Presenter: *Associate Professor of Industrial Engineering Program, at XXXXXX University.*
Workshop Abstract: This workshop covers basics of simulation and agent based simulation. The participant will use Netlogo® as an implementation tool. Basically, how to use the software to implement a multi-building energy system will be demonstrated. Participants will download Netlogo software and the test-case setup and learn how to develop the simulation model and setup the parameters for the building system. The participants will learn about fundamentals of agent based simulation and building energy systems.

Workshop-2
Title: The Role Leadership Competency in the Development of a New Professional Workforce
Presenter: Associate Professor of Teacher Education at XXXXX
Workshop Abstract: Today's competitive worldwide market and fluctuating work atmosphere demand that engineers possess leadership competencies in addition to mathematical, methodological and technical skills, and they must be able to understand project goals and have the ability to accomplish them with the ever plummeting availability of resources. For the most part, engineers learn leadership skills and dispositions while at work. In order to meet the demands of this changing world, most engineering programs are confronted with a myriad of barriers and challenges to generate innovative ways for instructional effectiveness so their program graduates are fully prepared to take on the many challenges twenty-first century engineers face. This presentation provides an overview and summary of leadership competencies that have been produced over the last 75 years and its relationship to engineering education. Some suggestions as to how these needed competencies may be implemented in engineering programs will be discussed.

Workshop – 3
Title: Green Lean Manufacturing
Presenters: Engineers of the Texas Manufacturing Assistant Center at XXX
Workshop Abstract: This 90-minute workshop will introduce participants to the systems of systems attributes of Lean Manufacturing. The participants will be led to a comprehensive approach to sustainable manufacturing that will also prepare them for a leadership role in sustainable manufacturing and environmental stewardship. In general, the following objectives will be achieved after this workshop – (1) Introduce Lean Manufacturing concepts, (2) Use Lean Manufacturing to identify environmental waste and (3) Apply Value Stream Mapping (VSM) as a systems of systems approach to analysis.

Workshop – 4
Title: Essential Ethics for Leadership
Presenter: MacGuire Distinguished Professor, Professor of Mechanical Engineering at XXXX
Workshop Abstract: This workshop covers the common ethical standards and some basic tools for making ethical decisions. Participants will identify ethical problems and use the tools to make decisions based on an ethical standard.

Workshop – 5
Title: Manufacturing Energy Efficiency for Future Engineers
Presenters: Associate/Assistant Professors of Department of Engineering Technology, College of Engineering at XXXXX University
Workshop Abstract: Within the broad paradigm of sustainable manufacturing, the issue of energy efficiency and conservation are addressed specifically in the workshop. We are focusing on increasing the efficiency of energy flows in manufacturing and industrial facilities with certain impact on both economic as well as environmental target variables. Inefficient energy use in manufacturing and industrial facilities is both increasingly expensive and unsustainable. Energy efficiency relates to reducing wasted energy, hence reducing energy consumption. Utilization of fossil fuels adversely affects the greenhouse gases released into the atmosphere and results in undesirable quantities of emissions. Increase energy efficiency will reduce the unwanted

environmental effects produced by manufacturing and industrial processes. Controlling energy use is important, but it is also important to assess or estimate it, and to understand methods and approaches for reduction its use and for assessing the cost effectiveness of these measures. The workshop also includes an improvement of resource efficiency as well since these energy flows are typically directly or indirectly connected with the depletion of critical resources (oil, gas, coal). The topic "energy efficiency in manufacturing" is of major relevance from a nation as well as a single company. On a national scale, industry is a major consumer for 33% of the national electricity in US. There is a strong need of appropriate methods and tools to support fostering energy efficiency in manufacturing companies. The student training for manufacturing energy efficiency improvement has become a workforce development initiative for creating the next generation of engineers. The main objective of this workshop aims at contributing towards the improvement of energy efficiency in manufacturing and providing training for undergraduate students in industrial processes, energy assessment procedures, and energy management principles.

Evaluation Method for Workshop/Seminar Series:

Participants: The targeted program participants were undergraduate and graduate master's students at various stages of their program with major emphasis on upperclassman. The majority of participants (85%) were undergraduates with 65 percent reporting being in their senior year and 38 percent of the participating students were female. More than 75% of the students reported Industrial Engineering as their area of concentration or major.

Research Design: The research design used to address this evaluation questions was a cross-sectional design that allows for the gathering of individual and group's perceptions and opinions about essential aspects of a program, issue, or intervention. This type of design is highly effective since it provides a quick and accurate "snapshot" of current subject's behaviors, attitudes, and beliefs from a particular population.

Instruments: As a means of assessing the quality of the individual workshop presentations, a general workshop evaluation scale was developed for each workshop with standardized set of items focusing on overall quality of presentation and presenter's level of effectiveness in conveying information as well as several open-ended questions with pertinent material related to each workshop's topic or issue. This evaluation scale consisted of 15 separate items that addressed the particular aspects of the plenary session presentations and the five seminar/workshops *(See Appendix A)*. An exploratory factor analysis of the evaluation instrument indicated that two major latent factors were extracted with one of the factors focusing on general effectiveness and quality of the presenter and the presentation itself (11 items) while a second factor described by 4 items focused on how the particular presentation addressed issues related to green energy manufacturing (4 items). The internal consistency of the 15-item total scale was 0.905 Cronbach's alpha. The alpha values for the two extracted subscales were 0.94 (Overall effectiveness of presentation) and 0.89 (Presentation addressed GEM issues). These results represent more than adequate indices of the scale's internal structure and internal consistency for the evaluation scale.

In order to assess the utility or immediate impact of each workshop, five content-based or "knowledge-based" tests of simple recall and understanding were developed for each workshop presentation addressing major concepts delivered by the workshop's presenters. A pre-test and a post-test research design were implemented to assess the amount of information acquired by the workshops' participants. Evaluators are keenly aware of the potential for inflated gain scores due to practice effects by participants but the results are still valuable to ascertain students' ability to maintain their attention on what is being presented. *Appendix B* presents these test specimens for each of the delivered workshops.

Data Analyses: Descriptive and inferential statistics were performed to address both the quality of the presentations and the measuring participants' levels of newly acquired knowledge derived from the workshops presentations. Means, standard deviations and percentages were used across the various scales' totals and subtotals.

The following section presents initially the findings obtained on how the participants rated the quality of the four different workshop presentations. Secondly, the section includes the findings gathered from the participants' gain levels on the four workshop presentations' conceptual content and skills.

Evaluation Results and Discussion

Overall Quality of Workshop Presentations

A total of 156 total valid responses were obtained from all 5 workshop presentations and plenary session with each presentation receiving an almost equivalent number of participant's evaluation ratings reported for each presentation workshop. To avoid naming actual titles or names of presenters the reader is referred to the workshop details furnished in previous section. There is also an overlap on the results below since same participant evaluated each workshop presentation that he/she was in attendance. Under each workshop, the frequency or count gives a general sample size (headcount) of students in attendance and who also chose to evaluate the session. Table 1 presents these observed distributions of participants' response rates for all workshops in the symposium.

Table 1: Observed distributions of participants' response rates for all workshops *Note:* Some rounding errors may affect total percentages

Presentation Workshops	Frequency	Percent	Cumulative Percent
Plenary Sessions	48	30.8	30.8
Workshop # 1	32	20.6	51.4
Workshop # 2	23	14.7	66.1
Workshop # 3	17	10.9	77.0
Workshop # 4	18	11.5	88.5
Workshop # 5	18	11.5	100.0
Total	156	100.0	

Percentage Allocation by Individual Item

In order to determine the perceived level of quality of all of the presentation workshops, Table 2 presents the percentages for each evaluation item in the scale and across the different scaling levels of quality. These results allow for the examination of how program participants perceived the delivery of all the workshops and plenary sessions in general. It was clearly observed that for almost all the evaluative items, the participants overwhelmingly rated the presentations as "good", "very good", or "excellent". In focusing on the scale's item # 14 and # 15, the participants' percentage ratings exceed more than 80% of them rated these presentations as well organized and of very good in their quality. No major issues of concern were obtained or observed from these participants' responses with the exception of items 10 and 11, which dealt with issues of queries from audience and conveying the topics efficiently.

Table 2: Percentage of participants' responses to individual items for all workshops presentations and plenary sessions. *Note:* Overall percentages do add up due to some students selecting the "Not applicable" option on each of the scale items.

	Evaluation Scale Statements (Internal Consistency for the overall scale was 0.91)	**Poor %**	**Fair %**	**Good %**	**Very Good %**	**Excellent %**
1.	Presentation clarified topic objectives	0	0.6	5.8	30.1	63.5
2.	Presentation covered topic content or information	0.0	0.0	9.6	25.0	64.7
3.	Presentation related topic to various GEM project challenges	0	0.7	6.0	37.7	51.7
4.	Presentation topic help apply theory to solve problems in GEM	0	1.3	7.9	32.5	53.6
5.	Presentation facilitated to develop new set of skills	0	2.6	10.3	30.8	55.8
6.	Presentation aided in the understanding of new concepts	0	0.6	14.1	25.0	59.6
7.	Presenter's delivery strategies were linked to GEM issues	0.6	1.3	9.3	31.3	51.3
8.	Presenter's comprehensive knowledge of topic presented	0	0.6	3.9	28.4	66.5
9.	Presenter's style of communicating information	1.3	2.6	12.8	31.4	51.9
10.	Presenter's response to questions/queries by audience	0.0	0.6	9.7	24.5	63.9
11.	Presenter's effectiveness in conveying topic concepts	0.0	1.9	8.3	33.3	55.8
12.	Presenter's material or handouts during workshop	3.2	1.3	8.7	30.0	54.0
13.	Presentation met GEM's program goals and objectives	0.6	0.6	8.7	29.3	54.7
14.	**Overall organization of workshop session**	0.6	0.6	7.7	**28.2**	**61.7**
15.	**Overall rating of this workshop session**	0.6	0.0	8.4	**29.2**	**61.0**

Upon examination of the total scale values using means and standard deviation scores, it is observed that participants' rated these fifteen scale statements as "very good" and "excellent" with very stable levels of variability. The lowest average was recorded by item # 7 dealing with the presenter's strategies being linked to GEM issues while items # 1 and # 8 being rated the highest. These items focus was on the presenter's background knowledge of the topic and the clarity of presentation objectives, see Table 3.

Table 3: Descriptive statistics for each evaluation item by participants on all workshop presentations and plenary sessions.

Scale Statements	n	M	SD
i1 Presentation clarified topic objectives	156	4.56	0.634
i2 Presentation covered topic content or information	156	4.53	0.757
i3 Presentation related topic to various GEM project's challenges	151	4.28	1.079
i4 Presentation topic helped apply theory to solve problems in GEM	151	4.25	1.166
i5 Presentation facilitated to develop a new set of skills	156	4.38	0.853
i6 Presentation aided in the understanding of new concepts	156	4.42	0.834
i7 Presenter's delivery strategies were linked to GEM issues	150	4.13	1.294
i8 Presenter's comprehensive knowledge of the topic presented	155	4.59	0.701
i9 Presenter's style of communicating information	156	4.30	0.883
i10 Presenter's response to questions/queries by audience	155	4.48	0.863
i11 Presenter's effectiveness in conveying topic concepts	156	4.41	0.810
i12 Presenter's material or handouts during workshop	150	4.22	1.169
i13 Presentation met GEM's program goals and objectives	150	4.19	1.287
i14 Overall organization of workshop session	154	**4.48**	0.810
i15 Overall rating of this workshop session	154	**4.48**	0.794
Valid Sample responses for this analysis	140		

Quality of Individual Plenary and Workshop Sessions

To further determine if there were differences between and among the five different workshop presentations and the plenary sessions from first day of conference, a breakdown across individual workshops was performed and Table 4 reports on these differences among workshops. The only presentation that received a moderate or fair average score in overall level of quality and was rated by the lowest number of participants was presentation workshop # 6 which focused on manufacturing energy efficiency for future engineers with the rest of the presentations receiving "very good" to "excellent" score averages. The top rated workshop session was the one about "Green Lean Manufacturing" followed by the workshop entitled "Essential Ethics for Leadership." For these two presentations, the participants appeared to have been able to relate well with the presenters and found a great deal of relevance with the content or presentation material. Figure 3 illustrates these descriptive statistics results graphically.

Table 4: Descriptive statistics of participants' perceptions about the overall quality of the workshop presentations and plenary sessions

Workshop Presentation	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Plenary Sessions	4.216	.088	4.042	4.390
Workshop#1- Agent-Based Simulation	4.467	.106	4.258	4.676
Workshop#2- Leadership Competencies	4.479	.121	4.239	4.719
Workshop#3- Green Lean Manufacturing	4.745	.138	4.472	5.018
Workshop#4- Ethics for Leadership	4.667	.138	4.394	4.940
Workshop#5- Manufacturing Energy Eff.	3.923	.158	3.611	4.235

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Selected Evaluation Items on Quality of Individual Workshops

In efforts to determine the overall quality of each presentation session, a further examination of presenter and presentation quality was analyzed by selecting a handful of scale items to hone in on the overall effectiveness of the plenary sessions and workshop presentation as rated by the participants of each workshop session.

Plenary Sessions

The plenary sessions included two major seminars delivered by researchers from *XXXX* Labs. Additionally, the, Associate Dean of the *XXXX*, delivered the keynote presentations on the

"Placement accuracy enhancement for the vision-guided robot" and "Mission effective analysis of armed helicopter-defense modeling and simulation".

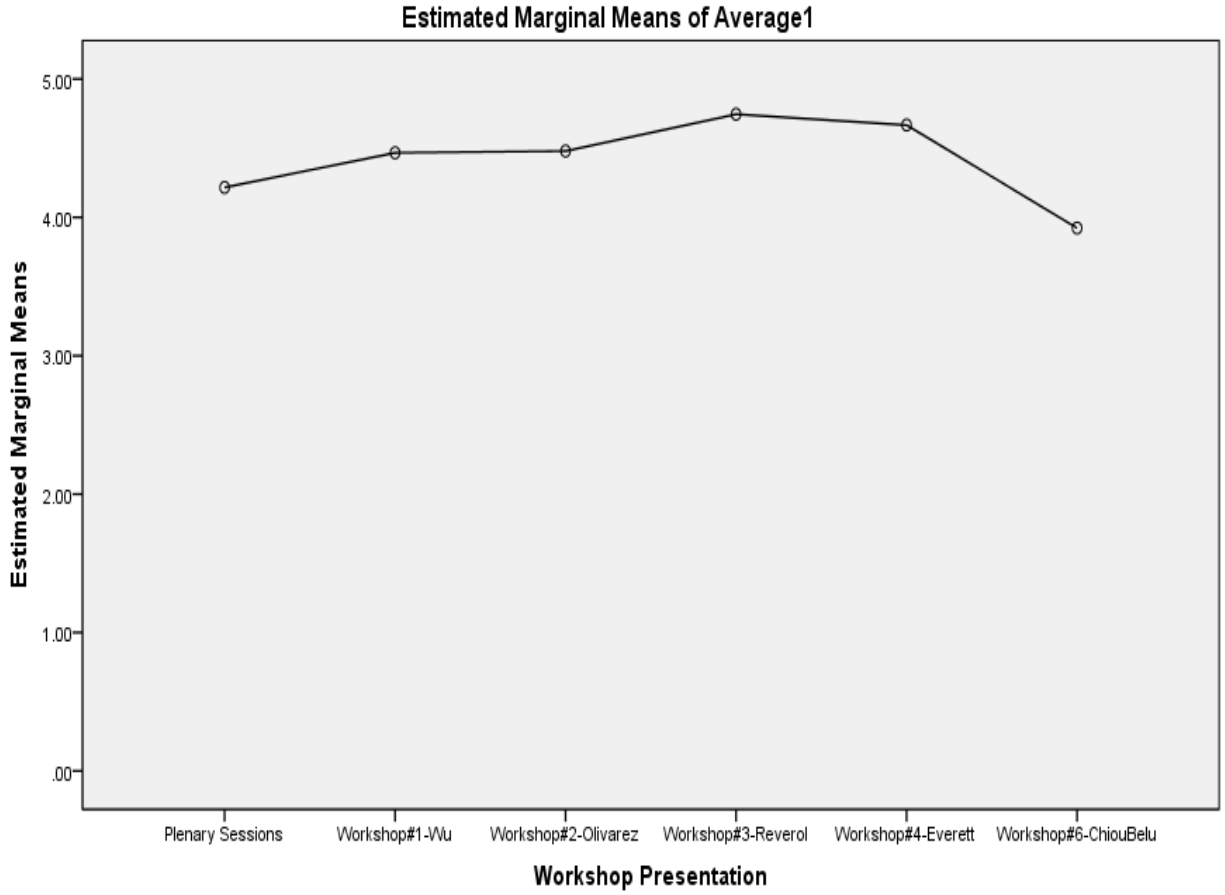

Figure 3: Depiction of overall level of effectiveness in all workshop presentations and plenary sessions.

They discussed current research trends and programs within *XXXXX* that focus on undergraduate, graduate, and doctoral, students as well as post-doc opportunities. Table 5 provides a general description of the 5 items that describe the participant's rating on these presenters' ability to deliver the content of their presentations effectively. A total of 44 to 48 responses were obtained for this section of the conference. The majority of the participants provided a high average rating on the overall organization of the session as well as high rating average for the quality of the session (M = 4.48, SD = 0.72; M = 4.39, SD = 0.68, respectively). All of the other selected evaluative items provided better than 4.0 averages rating for effective style of communicating information and meeting GEM's program goals and objectives. No knowledge quizzes were given to the participants for these presentations.

In efforts to determine the degree of new learning or knowledge acquired by the symposium's participants, individual statistical analyses were performed for each workshop presentation. The use of baseline (pre-test) data before the presentation is compared to data gathered after each presentation workshop (post-test). Due to some unforeseen time constrains, only two of the presentations did time allow for the administration and collection of the pre-test and post-data.

Workshop sessions #4 and #6 provided these types of data. The remaining workshops did not provided baseline (pre-test) information and basic descriptive statistics and inferential test of significance using a one-sample t-test were employed for the post-test data.

Table 5: Descriptive statistics on selected evaluation items for the plenary session presentations

Workshop Presentation: Plenary Sessions' Evaluation Statements	N	Mean	SD
i5 Presentation facilitated to develop a new set of skills	48	4.17	1.018
i9 Presenter's style of communicating information	48	4.08	.846
i13 Presentation met GEM's program goals and objectives	46	4.02	1.256
i14 Overall organization of workshop session	46	4.48	.722
i15 Overall rating of this workshop session	46	4.39	.682
Valid sample responses for this analysis	44		

Workshop # 1Findings (Development of Agent-Based Simulation for Building Systems)

This workshop covered some of the basics of simulation and agent-based simulation by demonstrating the use of Netlogo® as an implementation tool. Use the software to implement a multi-building energy system was demonstrated. Participants used Netlogo software and the test-case setup to learn how to develop the simulation model and setup the parameters for the building system. The participants in this workshop learned about the fundamentals of agent based simulation and building energy systems. This presentation was well received by the participants and received the highest best score in terms of overall total quality score (M = 4.47, SD = 0.47) in meeting the varied criteria for any presentation workshop in the conference. Additionally, the students were exposed to a large number of new concepts and hands-on approach to the use of the computer software for couple of simulation exercises. A few selected evaluation items on the quality of the presentation indicated that this workshop session was well organized (M = 4.38, SD = 0.75) and the overall rating for this session was very good (M = 4.41, SD = 0.62). The range of valid responses was from a low 30 to a high of 32 respondents attesting to the fact that they felt as having learned or developed new set of skills in this area of simulation research. The respondents also indicated that the presenter did a very good job on addressing the GEM's program's goals and objectives. Table 6 provides a general description of the selected 5 items, which describe the participant's rating on the presenters' ability to deliver the content of their presentations well.

Due to time constrains, the knowledge pre-test developed for this session was not given but the post-test was. Overall descriptive statistics are presented as to how students were able to perform after the presentation of this workshop. The participants' (n =28) performance on the knowledge test was found to be statistically significant between the baseline data points and the post-test administration [$t(27) = 12.97$, $\underline{p} < 0.001$], assuming a baseline average of zero. The 95 percent confident interval ranged from a low limit of 36.1 to a high limit of 50.0. The students who chose to complete the post-test exam appear not to have been able to make the appropriate connections between the content of the presentation and the exam items.

Table 6: Descriptive statistics on selected evaluation items for workshop session #1.

Workshop Presentation = Workshop # 1	N	M	SD
i5 Presentation facilitated to develop a new set of skills	32	4.50	.568
i9 Presenter's style of communicating information	32	4.47	.718
i13 Presentation met GEM's program goals and objectives	30	4.53	.629
i14 Overall organization of workshop session	32	4.38	.751
i15 Overall rating of this workshop session	32	4.41	.615
Valid sample responses for this analysis	30		

Workshop # 2 Findings (The Role Leadership Competency in the Development of a New Professional Workforce)

This presentation focused on issues for the acquisition of necessary competencies to become an efficient leader in the 21st century. The competitive worldwide market and fluctuating work atmosphere demand that engineers possess leadership competencies in addition to mathematical, methodological and technical skills, and they must be able to understand project goals and have the ability to accomplish them with the ever plummeting availability of resources. Various leadership skills and dispositions needed to succeed at work were presented. Additionally, presentation provided an overview and summary of leadership competencies that have been produced over the last 75 years and its relationship to engineering education. A large portion of the attendees to the presentation indicated having acquired new set of knowledge concepts and skills and it received the third best score in terms of overall quality (M = 4.48, SD = .68) in meeting the 15-item quality criteria for any of the presentation workshop in this symposium. As before, a few selected evaluation items on the quality of this presentation indicated that this workshop session was well organized (M = 4.70, SD = 0.47) and the overall rating for this session was very good (M = 4.65, SD = 0.71). There were 23 respondents indicating that they felt as having learned new set of concept in this area of leadership competencies for engineers. The respondents also indicated that the presenter did a very good job in communicating the myriad of leadership competencies and theories while the respondents felt that the presentation did not quite addressed the GEM's program's goals and objectives (M =3.91, SD = 1.76). Table 7 provides a general description of the selected 5 items, which describe the participant's rating on the presenters' ability to deliver the content of their presentations effectively. As in the previous workshops, the students were exposed to a large number of new concepts and ideas on the current theories on leadership and the multitude of competencies that are typically found in a good leader. Some of the general verbal comments obtained from the audience included aspects of opening the session to more interactive activities with the students and to allow some section for more questions and answers section.

The participants' performance on the post-test knowledge test was found to be statistically significant between the baseline data points and the post-test administration [t(26) =12.45, $\underline{p}$ = .001]. The mean difference from zero was 42 points, on average. The 95 percent confident interval ranged from a low limit of 35.0 to a high limit of 49.0 points. As in the previous workshop, the students who chose to complete the post-test exam were not been able to make the appropriate links between the content of this presentation and the post-test items.

Table 7: Descriptive statistics on selected evaluation items for workshop session #2.

Workshop Presentation = Workshop# 2	N	M	SD
i5 Presentation facilitated to develop a new set of skills	23	4.57	.788
i9 Presenter's style of communicating information	23	4.65	.487
i13 Presentation met GEM's program goals and objectives	23	3.91	1.756
i14 Overall organization of workshop session	23	4.70	.470
i15 Overall rating of this workshop session	23	4.65	.714
Valid sample responses for this analysis	23		

Workshop # 3 Findings (Green Lean Manufacturing)

The presentation was focused on issues of green lean manufacturing concepts with great emphasis on efficiency models, maximum flow, and waste reduction and responsible or clean manufacturing for any process and production of a product and its global impact. This workshop introduced the student participants to the system of attributes of Lean Manufacturing. The participants were led to a comprehensive approach to sustainable manufacturing by the application of the "Apply Value Stream Mapping (VSM) system, which will prepare them for leadership roles in sustainable manufacturing and environmental stewardship. Again, the workshop participants were given the opportunity to ask questions and they were also given a brief demonstration to illustrate these concepts. This presentation was well received by the participants and received the highest best score in terms of overall quality (M = 4.75, SD = 0.40) in meeting the varied criteria for any presentation workshop in the conference. Again, the students were exposed to a large number of new concepts that allowed them not only acquire new concepts but a new set of skills in this area of engineering. Furthermore, the students were exposed to a large number of new concepts and hands-on approach to the use the VSM system to green lean manufacturing situation. A few numbers of selected evaluation scale items on the quality of this presentation indicated that this workshop session was well organized (M = 4.76, SD = 0.44) and the overall rating for this session was excellent (M = 4.82, SD = 0.39). The total number of valid respondents (n = 17) demonstrated that they perceived as having learned a new set of skills in this area. The respondents also indicated that the presenter did a very good job on addressing the GEM's program's goals and objectives and communicated the concepts very efficiently. Table 8 provides a general description of the selected 5 items that describe the participant's ratings on his ability to deliver the content of their presentation in a very competent manner.

The participants' performance on the post-test knowledge exam on the topic of green lean manufacturing was found to be statistically significant between the baseline data points and the post-test administration [$t(18) = 20.86$, $\underline{p} = .001$]. The mean difference from zero was 75 points, on average. The 95 percent confident interval ranged from a low limit of 67.3 to a high limit of 82.4 points. In this particular workshop session, the students who chose to complete the post-test exam were able to make the appropriate links between the content of this presentation and the post-test items.

Table 8: Descriptive statistics on selected evaluation items for workshop session #3

Workshop Presentation = Workshop# 3	N	M	SD
i5 Presentation facilitated to develop a new set of skills	17	4.71	.588
i9 Presenter's style of communicating information	17	4.82	.529
i13 Presentation met GEM's program goals and objectives	17	4.59	.618
i14 Overall organization of workshop session	17	4.76	.437
i15 Overall rating of this workshop session	17	4.82	.393
Valid sample responses for this analysis	17		

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Workshop # 4 Findings (Essential Ethics for Leadership)

This workshop presentation had a simple goal of delivering a survey of general concepts related to ethical leadership and decision making by leaders. It extended a little over an hour on the various ethical concepts that a leader has to have in order to make appropriate decisions. This particular workshop covered some of the most common ethical standards and basic tools for making ethical decisions. The participants were involved in a collaborative or participatory activity by identifying ethical problems and apply the tools presented to make decisions based on ethical standards given certain scenarios or real-life cases.

Participants were allowed to take a very active and interactive role with the presenter including asking questions during the presentation. This workshop received the highest overall average (M = 4.67, SD = 0.42) in meeting the various aspects of a well-delivered presentation. As observed in previous workshops, a few selected evaluation items on the quality of this presentation indicated that this workshop session was well organized (M = 4.89, SD = 0.32) and the overall rating for this session was excellent with a perfect score (M = 5.00, SD = 0.00). A total of 18 respondents indicated that they felt as having learned different set of concepts in this area of essential ethics for leadership. The respondents also indicated that the presenter did a very good job in communicating the numerous ethical standards. Table 9 provides a portrayal of the selected 5 items that describe the participant's rating on this presenters' ability to deliver the content of their presentations effectively.

Table 9: Descriptive statistics on selected evaluation items for workshop session #4

Workshop Presentation = Workshop# 4	N	M	SD
i5 Presentation facilitated to develop a new set of skills	18	4.83	.383
i9 Presenter's style of communicating information	18	4.72	.461
i13 Presentation met GEM's program goals and objectives	18	4.28	1.602
i14 Overall organization of workshop session	18	4.89	.323
i15 Overall rating of this workshop session	18	5.00	.000
Valid sample responses for this analysis	18		

Although, participants (n = 25) had only a limited amount of time to acquire and discern the countless of concepts the presenter delivered the results of the knowledge test (pre- and post-tests) were found statistically non-significant [t(7) = 0.80, $\underline{p}$ = 0.45]. The mean difference for this workshop presentation was actually found to increase slightly from pre-test to post-test (M = 1.67, SD = 5.91). However, the inter-correlation between these two testing periods yielded a Pearson product moment correlation coefficient of r = 0.827. This result indicated a high level of test-retest reliability between the testing conditions. All in all, the large amount of material presented and the heterogeneous group of students who participated during this workshop session appears to indicate that some of the concepts presented were captured well but also indicated the need to over-emphasize them in a more in-depth or structured curriculum-based format. This will provide the students the opportunity for a much greater assimilation of these important concepts related to the essentials of ethical leadership.

In examining the overall participants' performance for this event, it was noted that a large number of participants provided information for the pretest but very few took the time or made the effort to complete the posttest component of this assessment. Only 8 students provided pre-test and posttest information and this small sample size may not allow as arriving at more precise conclusion as the overall effectiveness of the presentation by the use of this knowledge examination. Furthermore, there is a need to improve the degree of relationship that exist between exam measures to make them more relevant to the concepts presented in their intent to assess students' level of concept acquisition.

Workshop # 5 Findings (Manufacturing Energy Efficiency for the Future Engineers)

This final workshop presentation had a primary goal of delivering an overview of general concepts related to the broad paradigm of sustainable manufacturing, the issue of energy efficiency and conservation. The presenters focused on the ways for increasing the efficiency of energy flows in manufacturing and industrial facilities with certain impact on both economic as well as environmental target variables. The presenters indicated that increase energy efficiency will reduce the unwanted environmental effects produced by manufacturing and industrial processes. The presenters also includes an improvement of resource efficiency given that the topic "energy efficiency in manufacturing" is of major relevance at the national as well as a single company. The main objective of their workshop aimed at presenting current strategies that contribute towards the improvement of energy efficiency in manufacturing and the provision of the training of undergraduate students in industrial processes, energy assessment procedures, and energy management principles. Although, the overall respondent ratings were not as high as previous workshop sessions, the ratings observed were deemed in the range of "good" to "very good". The overall rating with the 15-item evaluation scale was close to a 4 or "very good" levels, (M = 3.92, SD = 0.68). As before, the presenters exposed the students to a large number of new concepts and interactive approaches on posing question throughout the presentation of new concepts. Again, a few selected evaluation items on the quality of the presentation indicated that this workshop session was satisfactorily organized (M = 3.72, SD = 1.41) and the overall rating for this session was adequately good (M = 3.78, SD = 1.40). The range of valid responses was from a low 16 to a high of 18 respondents showing that participants felt that they have learned or developed a new set of concepts and skills in this area study. The respondents indicated that the presenter did a good job on addressing the GEM's program's goals and objectives (M = 3.88, SD = 1.54) while respondents expressed in their ratings some level of

dissatisfaction with the presenters' style for communicating the content. Table 9 provides a description of the selected 5 items that describe the participant's rating on the presenters' ability to deliver the content of their presentations well.

Table 9: Descriptive statistics on selected evaluation items for workshop session # 5.

Workshop Presentation = Workshop# 5	N	M	SD
i5 Presentation facilitated to develop a new set of skills	18	3.72	.958
i9 Presenter's style of communicating information	18	3.22	1.166
i13 Presentation met GEM's program goals and objectives	16	3.88	1.544
i14 Overall organization of workshop session	18	3.72	1.406
i15 Overall rating of this workshop session	18	3.78	1.396
Valid responses for this analysis	16		

As in previous workshop sessions, the participants (n = 24) had only a limited amount of time to acquire, discern, and apply the countless set of new concepts presented, the participants provided valid data that produced results on the knowledge exam (pre- and post-tests) to be statistically non-significant [$t(7) = 1.08$, $\underline{p} = 0.32$]. The mean difference for this workshop presentation was found to increase slightly from pre-test to post-test. Although, there were 24 recorded data pieces between the pre-test and the post-test points, only 8 participants provided valid data for both test administrations. The overall gain scores for these participants in this workshop yielded a mean of 5.0 points with a standard deviation of 13.1 points and a 14 percent of the variance accounted for this intervention. The overall correlation index for these test administration was r = 0. 75 which is considered low given the pretest and posttest were basically the same and short span of time allotted between test administrations may have produced some carry-over-effects.

Examination of the overall participants' performance for this particular event, it was noted that few students provided complete test information for either the pre- or post-test times. The use of the same exam for both occasions may have led to the some degree of increase on the difference scores for this particular sample given that it happened within one- to two-hour period. Overall, the large amount of material presented and the different groups who participated during the workshop session appear to indicate that various important concepts presented were captured; however, there may be still a need for a more structured curriculum that allows students to the better acquisition of the same. Even though, there was not statistical significance the participants were able to produce more than 5-point gains between pre-test and post-test administrations. As in previous workshop presentations, there is a need to improve the degree of relationship that exist between exam measures to make them more relevant to the concepts presented in their intent to assess students' level of concept acquisition.

CONCLUSION

All in all, the maiden launch of this project based learning course & technical & leadership workshop series appear to indicate that participating students gained a tremendous amount of new concepts and applications related to green energy, green manufacturing and life cycle

assessment concepts. The workshops attracted a good number of graduate and undergraduate students with a larger representation derived from the undergraduate level group and those from the industrial engineering major or concentration. Some of the qualitative open-ended questions elicited similar comments and observations as indicating that the participants were satisfied or had acquired some new "knowledge", dispositions, and "skills" but these verbal comments were few and sparse across the different workshop presentations.

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Appendix A

Green Energy Manufacturing Workshop/Seminar
Workshop # 1: Evaluation Scale

Workshop Title: _____

Presenter: _____ Date: April 24, 2014

Instructions: In efforts to provide the best learning experiences through this workshop series, provide your candid and truthful appraisal of this presentation by rating the following statements of the workshop using the following 5-point scale values, circle your rating:

1 = Poor
2 = Fair
3 = Good
4 = Very Good
5 = Excellent
NA= Not Applicable

	Statements	1	2	3	4	5	NA
1.	Presentation clarified topic objectives	1	2	3	4	5	NA
2.	Presentation covered topic content or information	1	2	3	4	5	NA
3.	Presentation related topic to various *GEM* project's challenges	1	2	3	4	5	NA
4.	Presentation topic help apply theory to solve problems in *GEM*	1	2	3	4	5	NA
5.	Presentation facilitated to develop new set of skills	1	2	3	4	5	NA
6.	Presentation aided in the understanding of new concepts	1	2	3	4	5	NA
7.	Presenter's delivery strategies linked to *GEM*	1	2	3	4	5	NA
8.	Presenter's comprehensive knowledge of topic presented	1	2	3	4	5	NA
9.	Presenter's style of communicating information	1	2	3	4	5	NA
10.	Presenter's response to questions/queries by audience	1	2	3	4	5	NA
11.	Presenter's effectiveness in conveying topic concepts	1	2	3	4	5	NA
12.	Presenter's material or handouts during workshop	1	2	3	4	5	NA
13.	Presentation met *GEM*'s program goals and objectives	1	2	3	4	5	NA
14.	Overall organization of workshop session	1	2	3	4	5	NA
15.	Overall rating of this workshop session	1	2	3	4	5	NA

Additional items/questions on next page

How would you rate **your** knowledge of the subject matter or topic presented **prior** to the workshop? (Check one)

_____Not very knowledgeable about the topic(s)
_____Somewhat knowledgeable about the topic(s)
_____Very knowledgeable about the topic(s)

How would you rate **your** knowledge of the subject matter or topic **after** having attended this workshop session? Check one)
_____Remained not very knowledgeable about the topic(s)
_____Turned somewhat knowledgeable about the topic(s)
_____Became very knowledgeable about the topic(s)

Please provide your opinion on the following open-ended statements concerning this presentation.

What was the most valuable aspect of this workshop on *Agent-based simulation*? Please explain._____

What was the least valuable aspect of this workshop on *Agent-based simulation*? Please explain._____

What kind of behavior changes do you envision making as a result of this workshop, if any?_____

How will information gained in this workshop change/influence how your views *Green Energy Manufacturing* issues?_____

Additional comments or suggestions. _____

Demographics: Circle or complete.

Gender:	Male	Female		
Highest Degree:	Bachelors	Master's	Doctoral	
Undergraduate Classification:	Freshman	Sophomore	Junior	Senior
Graduate Level:	1st Year Master's	2nd Year Master's		3rd Year Master's
Doctoral Level	1st Year Doc.	2nd Year Doc.	3rd Year Doc.	4th Year Doc. >4th Years

Current Concentration/Major Area:_____

Appendix B: Example Workshops Content Knowledge Exams

Development of Agent-Based Simulation for Building Systems

Workshop #1 Knowledge Quiz **Student ID#_____**

For the following closed-ended multiple-choice questions, select the answer or choice that best reflect the stimulus question or statement. Circle your choice.

1. Three of the advantages for examining simple and complex systems via modeling include:
   a. Allows for comparison of alternatives, aids in the understanding of behaviors, replaces real system
   b. Allows for comparison of alternatives, simulates a system that may not exist, is inexpensive
   c. Allows for experimentation, Allows for control of extraneous factors, is inexpensive
   d. Allows for experimentation, not disruptive or destructive, aids in the understanding of behaviors
2. One of the most important benefits and purposes of simulation modeling is
   a. Difficult to introduce control in a system
   b. Difficult to predict system performance
   c. Predicts system misbehavior
   d. Predicts system performance
3. The difference between a deterministic model and a stochastic model is
   a. Inputs and parameters are well behaved rather than erratic
   b. Inputs and parameters are random rather than nonrandom
   c. Inputs and parameters are probabilistic and discrete
   d. Inputs and parameters are deterministic and continuous
4. One characteristic of a discrete event simulation model is that it is an
   a. Inferential models which helps us make inductive decisions
   b. Minimization model which leads to smaller errors in the system
   c. Optimization model that provides the best solution in a system
   d. Descriptive model as to how a system behaves
5. The key difference between Agent-Based Modeling (ABM) and Agent-Based Modeling and Simulation (ABMS) is
   a. An approach to model and simulate complex adaptive systems
   b. An approach to model and simulate complex systems by local action about the agents
   c. An approach to model and simulate complex systems by local action and interaction within an environment.
   d. An approach to model complex adaptive systems by local action about the environment
6. An agent within an ABMS setting is one who is an
   a. Asynchronous entity having the ability to decide actions for the environment
   b. Autonomous entity having the ability for decision-making actions and interactions to be implemented in the environment
   c. Authentic entity having the ability for decision-making actions and interactions to be carried out in the environment
   d. Atypical entity having the ability for decision-making actions to be implemented in the environment.
7. What exactly is the NetLogo model simulation software all about?
   a. A free-agent tool which studies the environment through simulation modeling
   b. A free-agent oriented programmable tool use for modeling real life simulations
   c. Free agent-based simulation environment modeling tool based on Logo language
   d. Free agent-based simulation environment modeling tool based at Northwestern
8. The following are four of the list of agents used for the Build Energy System (BES) example
   a. Building agent, generation agent, smart grid agent, battery agent
   b. Building agent, secret agent, generation Y agent, ice storage agent
   c. Outdoor temperature agent, ice melting agent, battery agent, free agent
   d. Outdoor temperature agent, ice storage agent, battery agent, smart generation agent

Appendix C
Sample LEGO Wind Turbine Life Cycle Analysis Modell Developed using GaBi™ Software