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Development and Application of a Systems Engineering Framework to Support Online Course Design and Delivery

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ABSTRACT

This paper develops a systems engineering-based framework to assist in the design of an online engineering course. Specifically, the purpose of the framework is to provide a structured methodology for the design, development and delivery of a fully online course, either brand new or modified from an existing face-to-face course. The main strength Systems Engineering provides to online course design and delivery is the holistic worldview and the life-cycle approach. Adopting the life-cycle approach ensures a smooth transition for faculty members who are in the process of modifying their curriculum to meet student and industry demands. The effectiveness and function of the framework is discussed with respect to results from a brand new fully online course that was designed and developed for the Engineering Management Program at University of Houston Clear Lake, including a survey of students on Blackboard efficiency. The paper concludes with a discussion of implications of the framework for online education and future research.

Key Words: Online Course, Systems Engineering, Framework

INTRODUCTION

Online education (OE) and learning has established itself as an independent discipline, due to the increasing demand from academia and practice alike. Universities more and more offer either blended or fully online courses and fully online degrees. The flexibility of online education

is especially appealing to working, professional adult students. Even though the data is scarce on the national profile of online students and their demographics, Mayadas, Bourne and Bacsich (2009) state that working adults are indeed the target population of online classes. The 2009 Sloan Consortium survey of online education reports that more than 20% of all students in U.S. Colleges enroll in at least one online class (Sloan Survey, 2009). The latest 2010 version of the Sloan Survey of Online Education states that almost 30% of higher education students take at least one course online (Sloan Survey, 2010). Academic research on the effectiveness and efficiency of online education is now published in journals solely dedicated for this topic, such as Journal of Asynchronous Learning Networks, American Journal of Distance Education, Quarterly Review of Distance Education, Advances in Engineering Education and Journal of Online Learning and Teaching, among others.

The recent announcement from the White House of the launch of *Change the Equation* initiative, a public-private partnership that is designed to increase literacy in Science, Technology, Engineering and Math (STEM), shows the level of importance STEM education has on society. The three goals this initiative works towards are 1) Great Teaching, 2) Inspired Learners, and 3) A Committed Nation (Change the Equation). According to the data provided by American Society of Engineering Education in 2009, bachelor's degrees in engineering remain unchanged since the previous year. A close look at the engineering disciplines, however, shows that fields related to *energy* have grown 150% since 2003. The report also shows that Master's degree in Engineering has grown 38% over the past ten years. Doctoral degrees, similar to Bachelor's, have been stable over the past three years. When considering that the target population of online degrees is working professional students, the growth of the Master's degrees awarded is expected. One of the ways to improve teaching and learning within STEM is to increase the availability of degree programs. Degree-awarding institutions are moving towards more flexible and advanced course delivery technologies in order to reach broader student populations.

A survey conducted by the *Instructional Technology Council* (2008) on the impact of eLearning at Community Colleges reports that there has been an 11.3 percent increase in the distance education enrollment between Fall 2006 and Fall 2007. The Seventh Annual Sloan Survey of Online Learning (2009) states that 73% of the institutions they surveyed (more than 2500 colleges and universities) reported an increased demand for *existing* online courses and programs, and 66% of institutions reported increased demand for *new* online courses and programs. In the same survey, it is reported that the demand for online offering is greater than that for the corresponding face-to-face offerings, and that 1 out of 4 higher education student has at least taken one online class.

ONLINE LEARNING AND EDUCATION

With current trend moving towards online education, particular attention needs to be paid to the issue of quality. According to a study conducted by Hirumi (2005), there are two distinct approaches to quality of e-learning: educational, or industrial. In other words, guidelines can be defined for programs and courses, measuring quality in terms of effectiveness and efficiency; or guidelines can be defined in terms of learners and learning objectives and quality is then measured in terms of increasing learner achievement and satisfaction. The mere fact that there is a distinction between educational and industrial perspectives to quality is enough to necessitate the need for standards and guidelines on how online courses could be designed and delivered.

The issue of quality was also discussed by Smith and Mitry (2008) who concluded that if university administrators do not remain committed to high academic standards, e-learning will never reach its true potential. With the increasing number of for-profit institutions who offer online degrees with the support of part-time instructors who may not always have the necessary terminal degrees from accredited universities (Smith and Mitry, 2008), it is crucial that truly academic institutions have to pay extra attention to highlight the strengths of online education, while fighting the challenges and limitations of online education.

The separation of students from each other and from the instructor by distance also brings forward certain issues. In a study conducted by Rabe-Hemp et al (2009), online learners have reported student isolation, lower levels of satisfaction, and more independent class preparation time compared to traditional face-to-face learners. Therefore, the efficient and effective design and development of an online course becomes increasingly important towards the success of student and instructor motivation and satisfaction. Wang and Chen (2008) report that design of online discussions, for instance, contribute to success of the online course. In a study conducted by Hu and Gramling (2009), students of a web-based course stated that goal setting and time management were the most helpful strategies to complete the online course. It is up to the instructor to design the online course in a way that helps the students with these important goals.

As Fish and Wickersham (2009) stated that the way instructors think about teaching and student learning needs to shift when teaching an online course. Aside from this difficult paradigm shift, another issue in designing an effective online course is the lack of knowledge of the instructor in terms of features and tools available through the medium in which the course is taught, such as Blackboard, WebCT, etc. The newest edition of Blackboard, *Blackboard Release 9.1*, brings several new or improved features, such as Course Wikis to enable active collaboration around course content and group projects, Blogs and Journals to promote conversation and reflection, the Blackboard

Connect™ platform to help students with time management through alerts, among others. It is the shared responsibility of faculty members to learn and incorporate these features into the design of the online course. The academic institutions also need to provide adequate training to the faculty members in learning these tools.

SYSTEMS ENGINEERING FRAMEWORK

The issue of online education within engineering is a complex topic with many stakeholders involved: the faculty, the students, the university, accreditation organizations such as ABET, and the industry. In order to ensure effective and efficient design of online courses, a robust foundation and methodology is necessary. The rigor that follows the use of a framework is also important for repeatability purposes, i.e. each time a new online course is needed, and same steps can be followed to ensure effectiveness and consistency in structure. Given that each class may not be similar in terms of requirements, delivery and topic, the generalizability of the framework is also an important characteristic and advantage.

In this research, concepts and processes from Systems Engineering have been applied to the topic of online course design, development and delivery in order to develop a framework that academicians could use. Some universities may not have a support structure for the faculty; such as providing workshops and seminars on efficient and effective online teaching. As Fabry (2009) suggests, the issue of effectively utilizing the features and tools of the design and delivery mediums, such as Blackboard, needs to be addressed by course developers. The proposed Systems Engineering Framework (SysEF) is intended to provide a structured methodology for the development of a fully online course, either brand new or modified from an existing face to face course. Using such a framework is also necessary to ensure that all stakeholders are aware of their roles and responsibilities within online education.

The rationale behind using Systems Engineering as a foundation for the framework is based on the main concepts of systems engineering, as identified in Blanchard (2008):

1. *Holistic view*: Looking at the system of interest as a whole, from a top-down approach is necessary and useful to build successful systems. Considering all aspects of online course development and delivery is crucial for effective and efficient online courses.
2. *Life-cycle orientation*: Addressing all stages of successfully developing and implementing a system, starting with conceptual design and ending with phase-out, will also provide support in OE, since online course delivery also has a temporal component, i.e., design of class, starting the class, finishing the class.

3. *Identification of system requirements*: Identifying clear and complete user requirements and establishing traceability to specific system goals is the key for successful systems. The initial design stages become crucial in identifying the requirements. Identifying the requirements of students and the class, establishing requirements for online course development and delivery, and transferring these requirements into conceptual design goals reduces the probability of making errors later on.
4. *Interdisciplinary effort*: Identifying the different components and the interrelationships between these components of the system will require collaboration of different teams. From an OE standpoint, these different disciplines and teams may be the faculty, the administrative and communications and technology personnel, among others.

Systemic View

The first step in developing the SysEF starts with the identification of the *system*. A system, as defined by International Council on Systems Engineering (INCOSE) is "a combination of interacting elements organized to achieve one or more stated purposes" (INCOSE Handbook, Version 3.2, 2010). A system will have an *input*, which represents the need; an *output*, which represents the system responding to the determined need; *constraints*, which are external variables imposed on the system; and *mechanisms* or *resources* that are required to develop and deploy a successful system (Figure 1).

One of the general characteristics of any system is that the system consists of a *hierarchy*; for instance, a system is composed of different *subsystems,* these subsystems are composed of

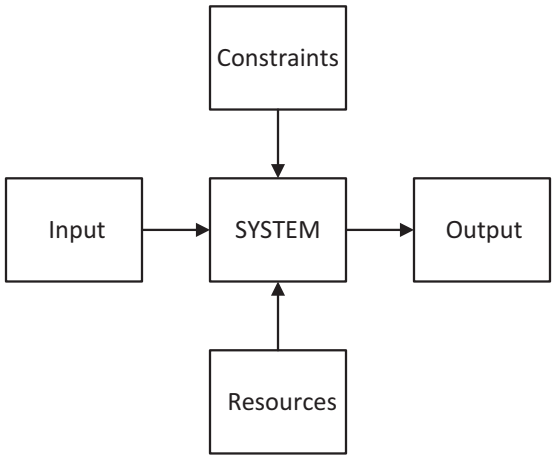

Figure 1. The system (from Blanchard, 1998)

Key Concepts	yste s e n t on	e n t on
Input	I nt t n u nt t	u nt t u t u t tu nt t n un nt t n u t
t	n t n t t pu p	nt t n t p p t nt u
utput	t t t t n n t n	p n n n n t n n m nt n n

Figure 2. System Definitions

different *components,* and these components are composed of different *parts*. All of these different levels of hierarchy add to the complexity of a system, since the items within the hierarchy will also have interrelationships. The concept of hierarchy is also applicable for an online course. The main concepts are summarized in Figure 2 and explained below:

- The *policies and procedures* may be university rules and regulations, or accreditation standards that act as constraints. The instructors and the students have to abide by these policies and procedures.
- The *system* that is the focus in this paper is an online course development and delivery system, indicated by Course A. Some examples of the different levels of the hierarchy are described below:
- The content, administrative, documents, assessment and delivery medium are the *subsystems* that come together to form the system. Each subsystem will consist of different components.
- Content will include topics to be discussed, course modules, and the schedule for the entire semester. Each course module will be composed of different topics, and each topic contains course objectives that can be traced back to course outcomes, thus completing the system hierarchy.
- The Administrative subsystem will include the faculty member's class policies and procedures, Instructor's Manual, Test Bank, and other instructor-related materials.
- The Documents will include any document that will be distributed to the students, such as the syllabus, course slides, the textbook and additional reading material (journal papers, magazine articles, etc.).

- Assessment subsystem consists of material that will be used to evaluate the students' knowledge, such as homework, exams, case studies and group projects.
- Delivery medium is related to the interface that is being used to design and deliver the online class. This could be either WebCT or Blackboard, and will include technical requirements (such as whether the interface works better with Internet Explorer or Mozilla Firefox), student accessibility, and communication channels between the instructor and the student, as well as among students.

Figure 3 represents the systemic view of adapting a face-to-face class to an online class.

Life-Cycle Orientation

Once the "systemic view" is established, i.e. the system (and the hierarchy) is described; the life-cycle phases are then identified and discussed. The Systems Engineering Life Cycle (Faulconbridge and Ryan, 2003; Blanchard, 1998) consists of five main phases, bounded by identified need and retirement and phase out from beginning and end, respectively (Figure 4).

The key tasks and elements of each of the phases are described following Faulconbridge and Ryan (2003), and Blanchard (2008). The *Conceptual Design* stage involves identification of stakeholder

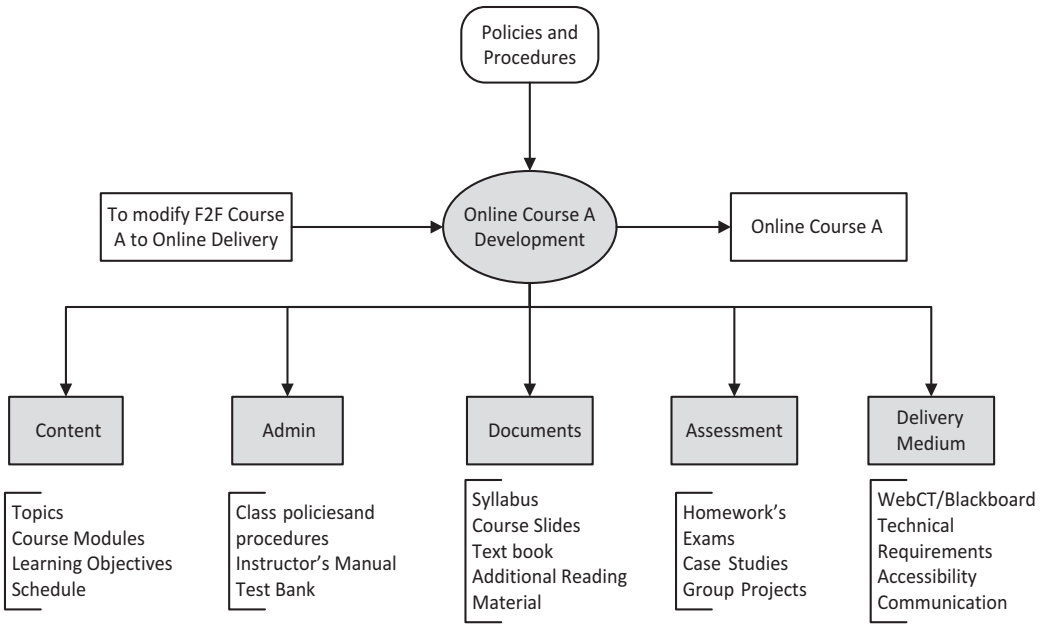

Figure 3: Systemic view of Online Course Development

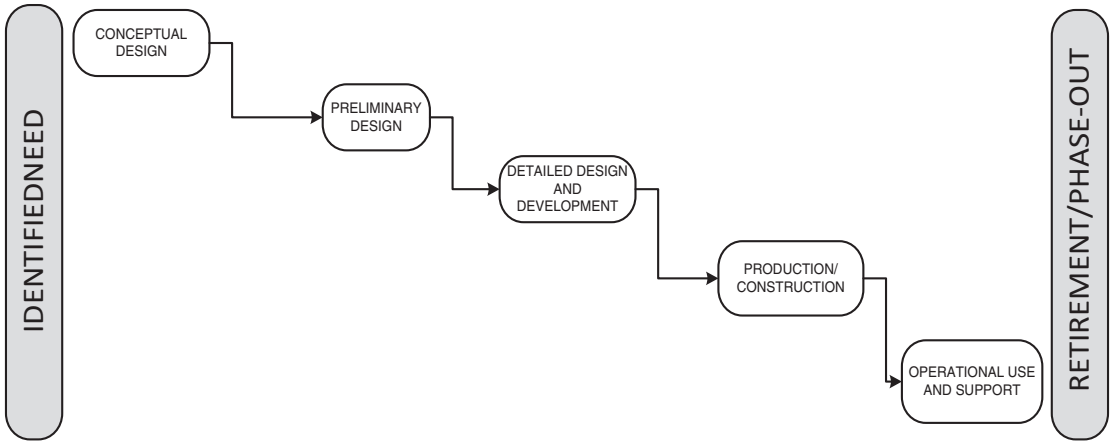

Figure 4: Life-cycle approach

requirements, conducting feasibility analysis, conducting requirements analysis, a system-level synthesis and performing a system design review. The *Preliminary Design* stage involves the subsystem requirements analysis, requirements allocation, interface identification and design, subsystem-level synthesis and preliminary design review. The third stage is *Detailed System Design and Development.* In this stage, development specifications are revised, detailed requirements for units, assemblies and components are defined, detailed interface requirements for interfaces are identified, product specifications are produced, detailed design of units, assemblies and components are produced, prototypes are built and integrated, and product, material and process specifications are finalized. Once these steps are completed, *Production and/or Construction* stage is reached. This stage involves production and/or construction of system and components, supplier production activities, system distribution and operation, operational test and evaluation, customer service issues and data collection and analysis for future use. The last stage, *Operational Use and Support*, is where the system is put into operation in the "user" environment. Tasks that take place in this stage are logistic support, operational test and evaluation, data collection and analysis, system or subsystem modification if necessary, and customer service activities.

The different phases of the life-cycle can be adapted directly to the design and delivery of an online course:

- *Identify the need:* The need for an online course will be identified through different systems engineering methods, such as conducting a market analysis, taking into consideration the short

and long term goals of the academic institution and demand from industry partners, developing questionnaires and conducting surveys. The profiles of the students registered in the course should also be taken into consideration. The instructor could design a course differently if the students are full-time or part-time, international or domestic, continuing education, etc.

- *Conceptual Design:* Once the general need is established, the requirements of different stakeholders have to be identified to proceed with the design of an online course. The stakeholders involved in an online education context will be the students, the faculty, the institution, and the industry. Expectations and requirements of each of these stakeholders have to be identified clearly in order to have a successful online course (Wilkes, Simon and Brooks, 2006). This analysis will also include the number and content of each course module, each topic, and expected course outcomes. The feasibility analysis will include whether the nature of the course is appropriate to be delivered in an asynchronous, fully online manner. Reuter (2009), for instance, conducted a research on a science course that had lab and field components, and compared the learning success of online and on-campus students. The results from this study showed that students from both populations met the learning objectives for the course, with online students showing more improvement in variables such as pre- and post- assessments. Despite the highly interactive and applied components of this course, it was designed and delivered as a successful online course. Availability of textbooks, reading material, additional sources, instructor's manual, test banks, Wiki materials and any other course material have to be identified in this step. Other policies, such as required technical skills or any prerequisites for the course should also be determined at this initial step. Once it is established that the course and all its components can be adapted to an online course, the design phase can move forward.
- *Preliminary Design:* One of the main components of preliminary design is the identification of the interface. The selection of the course management system and the delivery medium will depend on the policies and procedures of the institution, as well as the availability and appropriateness of the tool chosen to the goals and objectives of the faculty members and the students. Interfaces such as WebCT, Blackboard, Wimba Live Classroom or Adobe Connect have their own advantages and disadvantages, and these may be evaluated through the use of trade-off analysis, a decision matrix or any other tool that allows for multiple objectives. The detailed components of the class, such as the course documents, reading material, assignments and assessments that are aligned with the learning objectives within each module, are determined at this stage.
- *Detailed Design and Development:* Once the course modules and contents are near complete, the level of detail required in each of the components starts increasing. For instance, in this

phase, for each course module, suggested dates should be selected to give the students an idea on how long they should take to go over the material for that particular module. In a study conducted by Calvin and Freeburg (2010), adult learners have stated that they have difficulty in time management while taking web-based courses. Providing more temporal structure and direction to the students for each session or each module is crucial when designing a fully online course. The same study reports that having clear instructions for assignments would help increase the success of an online course. A list of activities, assignments or assessment that will be linked to each module should also be available, as well as how these assignments will be evaluated, in what format any feedback will be given, has to be decided.

- *Production and/or Construction:* In this step, the required readings, course documents, assignments and assessments, the syllabus, course outline, and any other material that will be used by the students and/or the instructor are gathered and the interface that was selected can begin to be populated. At this point, the delivery medium is not being made available for the students yet. The instructor, however, starts to put all the course content onto the interface. The final output of this stage can be considered as a *prototype* of the actual online course. The instructor may also be able to see this medium from the students perspective (by switching off the "edit" mode in Blackboard, for instance) to ensure that the course is easily accessible and can be navigated without any technical or design problems.
- *Operational Use and Support:* The final phase of the lifecycle is where the online course is made available to the student at the beginning of the semester, which means that the system that was designed and developed, i.e. the online course, is now being delivered. One of the main activities of this stage is support, which starts with ensuring that all communication channels between the faculty and the student are open. This also includes the technological support center of the academic institution, where students can get help for any technical problems they may encounter.
- *Retirement and Phase-Out:* The closing of the life-cycle is when the online course is no longer available to the students, after student grade resolution is complete, which is mostly at the end of the semester. The course may be migrated to the next semester, or may be kept on hiatus until it is offered again. Since a great amount of information is available online, in order to avoid the loss of information because of any technical glitches or extreme weather-related events, all course content should be stored externally, outside of the intended interface.

Identification Of System Requirements

Determining the user requirements in the beginning stages of online course design and development is extremely crucial. A course is a system of objectives and outcomes. Tracing the course

outcomes back to the course objectives is an important factor, and can only be established if the user requirements are translated into outcomes in the beginning. The web tool used to design and deliver the course should allow for this traceability of objectives to the course modules that produces the outcomes.

Support Structure

Full and successful implementation of these concepts and principles depends on both *technological* and *management* issues, similar to systems engineering (Blanchard, 1998). Without adequate and appropriate people and organizational support, the technological tools and models will not be efficient, or may not be applied successfully. Integration of necessary organizational support is crucial when identifying which components are going to be needed when designing, developing and deploying the system. This includes the maintenance and modification of course content and material according to semester, student profile, etc. New content may be added, reading material may be updated.

From the technical perspective, computing and communication services, or computing and telecommunications centers within academic institutions will ensure effective and efficient design and delivery of online courses. However, without effective management support, the technical components cannot survive in isolation. The strategic goals, as well as short-term goals and objectives of the institution have to be aligned with the goals of the degree programs, so that they receive organizational and administrative support from their institution. Research shows that online education proves to have a significant effect on budget issues that favors the university. Betts, Hartman and Oxholm (2009) have identified several economic factors that drive the enrollments in online and hybrid programs. Tuition, state funding, financial aid and endowments are among the many factors that impact enrollment in these non-traditional programs. They further state that in order to provide long-term sustainable programs, the colleges and universities should balance academic quality and accountability with online education. However, a report through the Sloan Foundation (The Sloan Survey, 2009) shows that the trend for institutions and universities to include online education as part of long-term strategy and goals has been almost a plateau. One of the reasons for this may be the fact that advertising and promoting an online program is expensive and institution may be constrained to support a budget for advertising. Online education may be within the long-term goals of an institution, but they may not be ready for follow up with the maintenance and modification budgets that are required to support the online program. The continued success of online degree programs and gained support from industry partners and collaborations will also motivate organizational support.

All of the components described above supports the development of the Systems Engineering Framework (Figure 5). The systemic view establishes the definition and boundaries of the system,

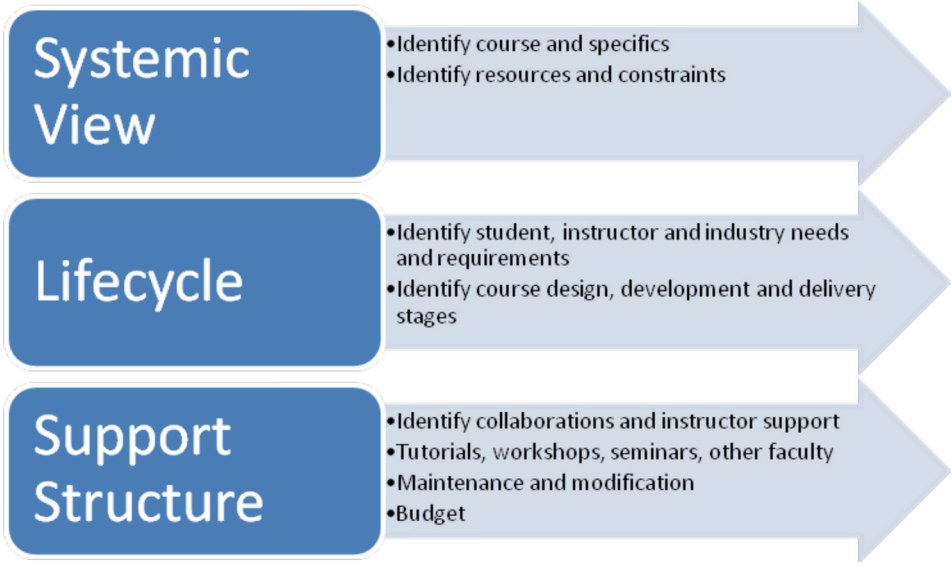

Figure 5: Systems Engineering Framework

the subsystem, the components, and the constraints that are imposed upon the system; the life-cycle starts with the identification of a need, and is followed by the conceptual design, preliminary design, detailed design and development, production and/or construction, and operational use and support phases.

APPLICATION OF THE SYSTEMS ENGINEERING FRAMEWORK

The developed SysEF was used to facilitate the design and development of a *Technology Planning and Management (TP&M)* course offered as part of the Engineering Management Program curriculum at University of Houston Clear Lake (UHCL). The course is a three-credit, graduate-level course that is one of the core requirements of the Master of Science degree offered through the Engineering Management Program in UHCL. The Fall 2010 semester is the first semester that the Engineering Management Program of UHCL is offering a fully online Master's degree. The students who wish to complete this 100% online program should be able to take all the required and elective courses asynchronously, through Blackboard. Transferring all face-to-face courses into fully online courses is, therefore, extremely important for the quality and success of the degree and the program. Degree of satisfaction and success of the students that have enrolled in the online courses depends on the way these courses are structured, offered and maintained over their life-cycle.

Systemic View

The components of the systemic view are the system itself, the input to the system, the output from the system, and the constraints and resources that impact the system itself. The *input* is the *need* for the online course that is being developed. Since the TP&M course is a core requirement, it needs to be available in a fully online format to the students who wish to complete the 100% online Master's degree. The *output* will be the TP&M course on Blackboard ready to be delivered to the students. Figure 6 is an overview of the system hierarchy.

System: Online Technology Planning and Management course.

Description of the system: The TP&M course introduces the student to the fundamental skills, knowledge and practices that make up the body of knowledge for engineering and technology management, innovation management and strategy. The course is intended to build the foundations of strategic management of innovation and new product development.

Subsystems*:* Content, Administrative, Documents, Assessment, Delivery Medium.

Components*:* Content will include topics, course modules, learning objectives and the schedule. Administrative will include class policies and procedures, instructor's manual and the test bank. Documents will include the syllabus, course slides, textbook and additional reading material. The Assessment will include homework's, exams, case studies and group projects. Delivery Medium will be Blackboard, and will also include technical requirements, accessibility and communication tools. Some of these components are described below:

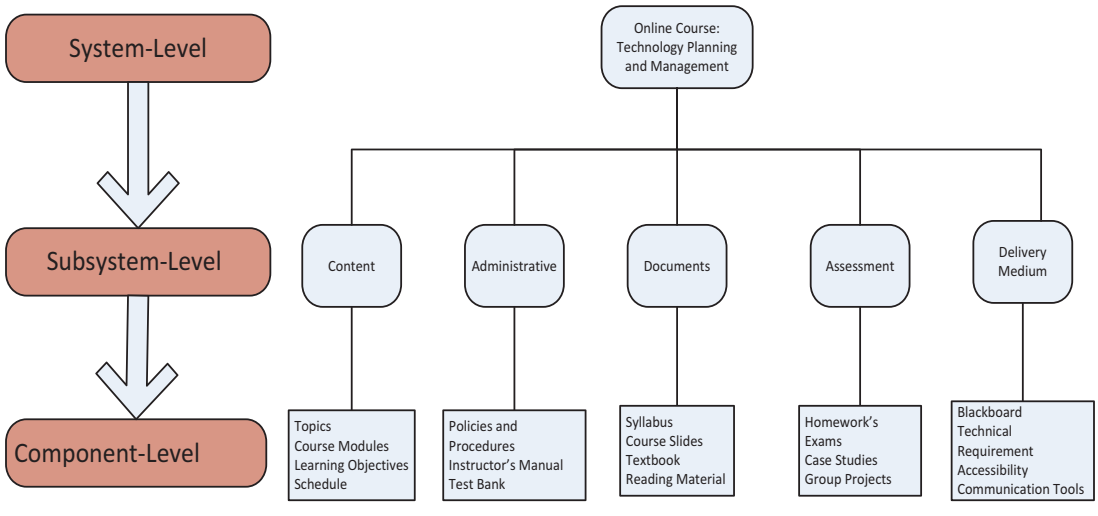

Figure 6: TP&M Online Course Systemic View

- Topics include processes for implementing innovation, the effects of organizational components on technological innovation and formulating and implementing technological management strategies, among others.
- The course is divided into three main sections: Section 1 is related to the dynamics of technological innovation, where the sources, types and patterns of innovation, as well as dominant design and timing of entry are discussed. Section 2 is about formulation of the technological innovation strategy, where topics such as defining a strategic direction, how to choose innovation projects, and how to protect innovation are discussed. The final module, Section 3, is on the implementation of the previously developed innovation strategy. This last phase of the class covers topics such as managing new product development processes and teams.

Life-Cycle Orientation

The life-cycle of an online course, as discussed above, consists of identifying the needs, conceptual design, preliminary design, detailed design and development, production/construction, operational use and support, and retirement.

Identifying the Stakeholder Needs: This is the initial stage of the course design and development where the instructor gathers information and data on what is needed in this course. The main stakeholders identified were Faculty, Students, University, and Industry. Through discussions with the Program Chair, the place of the course within the overall curriculum of the EM Program was established. The faculty members saw the need for a Technology Planning and Management course that would provide a higher-level analysis on strategic technology management. The number of students and the profile of the students (international or domestic, working professionals or no experience, etc.) are also included in stakeholder analysis. The need for an online course would fill the needs of both the university, and the industry. According to data received from Office of Institutional Research at University of Houston Clear Lake, the student profile of the Engineering Management Program is shown in Figure 7:

As seen from the profile, the majority of students are residents, who are working professionals. Providing an online course would add the necessary flexibility to the part-time students, and also allowing the industry to provide employees with the opportunity of receiving a higher degree. The student profile, as well as university and industry expectations from an online Technology Planning and Management course was also reflected in the applied nature of the course design. The students are provided with a case-based course that uses relevant and current bodies of knowledge as sources. Using examples from the current business world, relating course topics to the profession of students, as well as contributing to the knowledge of full-time students who are looking to find jobs after graduation, were all part of the course design.

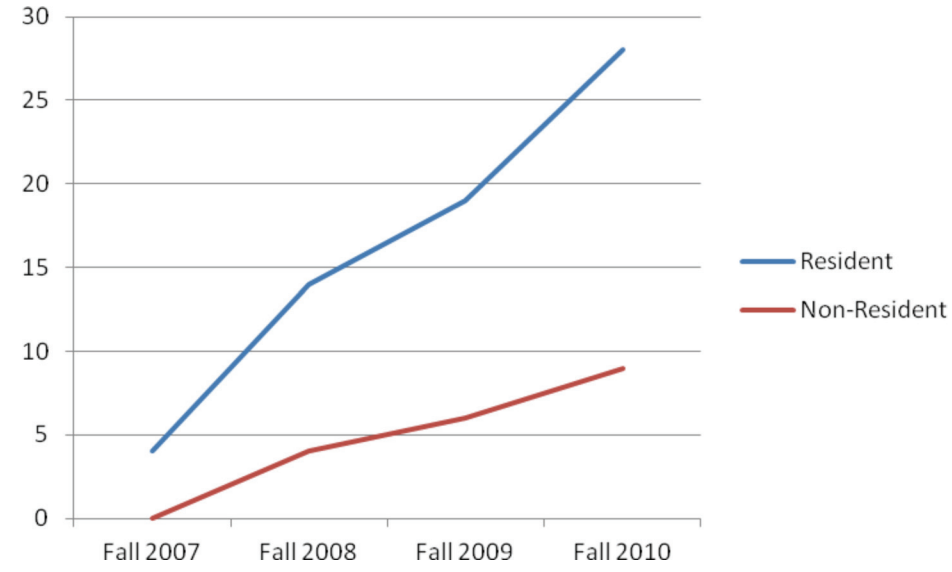

Figure 7: Graduate Student Profile of Engineering Management Program

Conceptual Design: This stage is where the functional design of the system at hand is analyzed, in other words, what the system needs to do, and how well, is established. Some of the steps include identification of stakeholder requirements, feasibility analysis and requirements analysis. These will be different for each university; however there may be common points that are required for each course. For instance, every course is required to have a syllabus. Every syllabus is required to contain learning objectives, university policies and procedures regarding disabilities, incomplete grades, add/drop deadlines, etc. Each of these requirements should be specified in this section.

Examples of the overall learning objectives for this course are identified as follows:

- Understand the foundations of technological innovation
- Understand the industry dynamics of technological innovation (sources of innovation, types and patterns of innovation, etc.)
- Explore methods of formulating a technological innovation strategy
- Learn ways to successfully implement a technological innovation strategy

Preliminary Design: Following the conceptual design, the system-level requirements are now translated into design requirements for subsystems. The system hierarchy becomes more evident and important in this stage. Having decided on what the overall goals and objectives of the TP&M course are, now the individual learning objectives of each course module have to be specified (Figure 8).

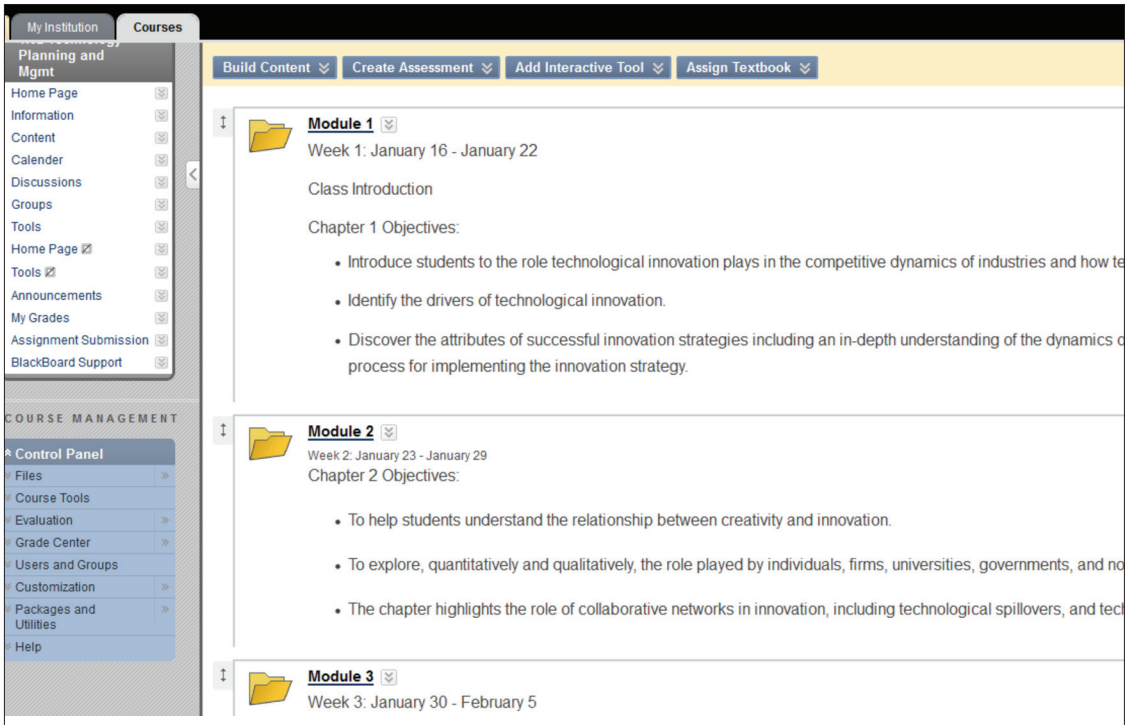

Figure 8: Preliminary Design

These individual learning objectives are presented to the students for them to have an idea on what is going to be covered in each module. Each of these objectives is discussed in class through cases and examples. Assessment of students with respect to these objectives is done within class, where class participation is graded, and also through weekly assignments. These weekly assignments contain reading a short case study that is provided by the instructor, and answering discussion questions that are related to the topics covered in class, which are also presented within the short case study. In other words, the students are evaluated on their participation in short exercises and discussions within and outside of the classroom in a weekly manner.

Detailed Design and Development: Following the preliminary design stage, an online course shell is now created and ready for the instructor to start populating it with design features that are necessary for the course Components such as contents for course modules, discussions, groups, announcements, means of communication, etc. (Figure 9)

This Figure also shows the activities the students are required to perform for their course requirements. For modular assessment, individual Homework's were provided as weekly assignments. A Mid-Term Project is assigned, in which the students are required to research three current examples that are related to the course material covered, and discuss these examples. For instance, they can

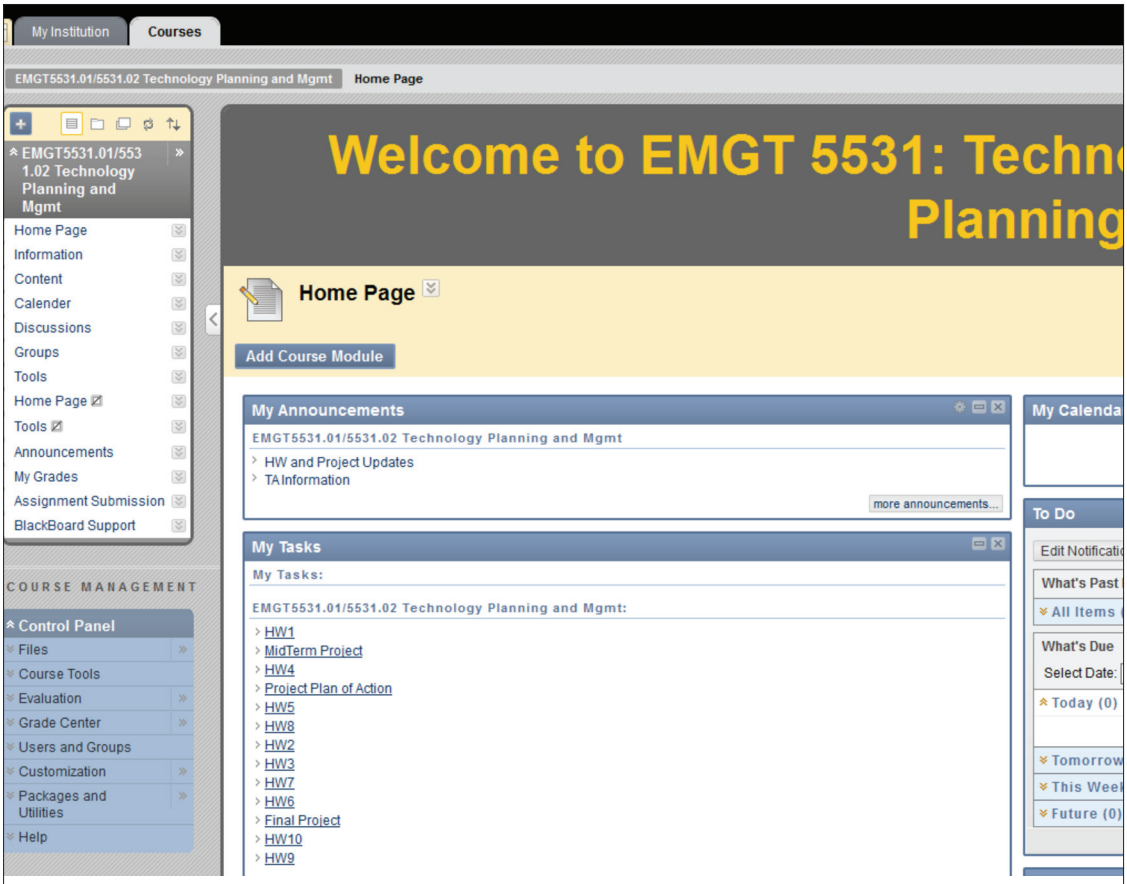

Figure 9: Detailed Design and Development

choose Disruptive Technologies, and discuss Red Box, Blockbuster and Netflix. As a Final Project, which is group work, each team is required to present a technological innovation they have created, and discuss their strategies and implementation of the strategies if they were to produce this product or provide this service.

Production/Construction: Once the preliminary design is complete, the course shell is now ready to be populated with actual course material. For instance, as seen in Figure 10, the Content section is now divided into different course modules for each week. Under each module, the students will find the slides for that week, additional reading material, and any other extra material necessary. For instance, for the TP&M course, each week an innovation is given to the students for them to discuss in the discussion boards, under the heading "Innovation of the Week".

Operational Use and Support: Throughout the course duration, the instructor updates the course modules, posts and grades assignments, checks the Discussion Board for student participation, and

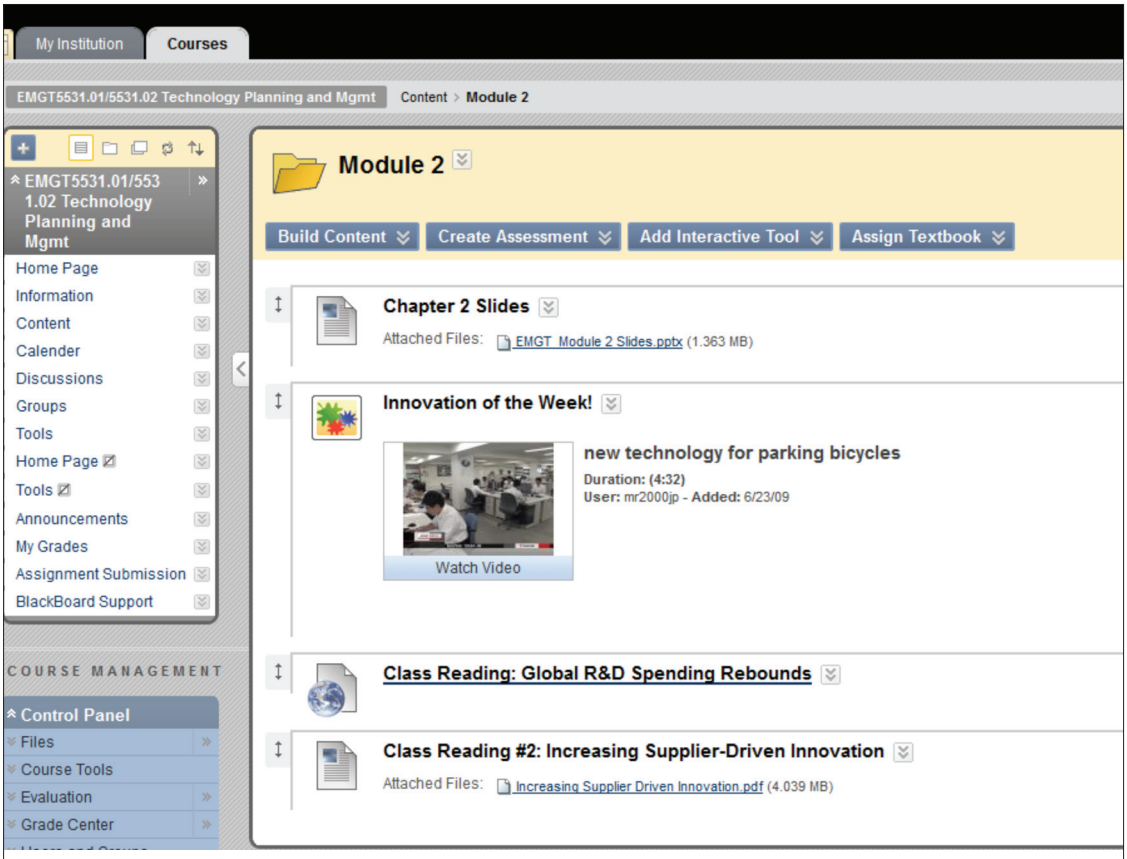

Figure 10: Production/Construction

manages any other course activity necessary. Maintenance and support is provided by the Computing Technology division of the university.

Retirement: Once the course is finished, the created Blackboard shell is saved, and may be transferred into another semester where the course would be offered again. The phase-out/retirement stage concludes the system life-cycle.

Support Structure

Once the online course is fully functional, in order to keep it that way, the support structure needs to be in place, both for faculty and for the students. Help links for both Blackboard Support and for school-wide support in general are made available for the students to use. In addition to keeping the online course functional during delivery, once the semester is over, the course is once again put into the production server where modifications can be made for future semesters.

ASSESMENT OF THE FRAMEWORK

In order to evaluate the value of the framework that was applied to an online course, a brief survey was developed and distributed to students who took the course with the aid of Blackboard. The survey consisted of questions intended to evaluate the efficiency and effectiveness of a Blackboard course designed and developed using the framework.

Sample And Survey Description

The survey consisted of questions such as "When using Blackboard, I could easily find the documents I needed" and utilizes a 5-point Likert scale consisting of "Strongly Disagree", "Disagree", "Neutral", "Agree" and "Strongly Agree". The sample chosen consisted of Spring 2011 and Summer 2011 Master's students at the Engineering Management Program at University of Houston Clear Lake. The students were asked to participate in the survey after the completion of the semester, and their participation was anonymous and voluntary.

The survey was developed and distributed using SurveyMonkey. Using an online survey medium such as SurveyMonkey was chosen to increase the participation and response level. An e-mail that contained the survey link and a brief description of the research objectives was sent to all of the students. In order to ensure a high response rate, a second reminder e-mail was sent after two months. Out of 30 students that the survey was sent, 16 of them completed the survey, making the response rate around 53%. From the students who completed the survey, there were 7 who took more than 4 courses that used Blackboard, 4 of them stated that they took 3 courses using Blackboard, 2 of them took 4 courses, 2 of them that book 2 courses, and only one student took just one class using Blackboard. From this profile, it can be seen that the students have had different levels of experience with Blackboard.

Survey Results And Discussion

The overall results of the survey indicate a positive attitude towards the course that was developed using the framework.

Ease of use

The highest agreement within the students was for the question "The organization of the course into modules made it easier to access the material", with 75% of the students agreeing, and around 18% of the students strongly agreeing to this. Dividing the semester content into weekly or monthly modules is a decision that would depend on the instructor. However, the systems engineering framework is set up in a way to ensure that at the Component Level, the smallest items are available. This

is also connected to the "system hierarchy" concept, which was also reflected in the framework. In the question on whether the hierarchy of folders made it easier to find information, 38% of the students agreed, and 19% of the students strongly agreed.

Flexibility

Using an online medium such as Blackboard has also provided support for students who are working professionals – such as the Engineering Management Program students in UHCL – in terms of flexibility. When a student misses class due to prior work engagements, they can use the detailed module of that week and be up to date with the course. According to the survey, 50% of the students agreed that using Blackboard provided flexibility when they could not attend the class, and 38% strongly agreed to the same fact.

Supportability

As discussed above, in order to keep the online class functioning as intended, a support structure is necessary. The course is set up by the aid of instructional designers, and information on how to get support in case of a technical difficulty was provided to the student within the Syllabus, and also in the main course page in Blackboard. One of the survey items, "Technical problems were solved quickly by the faculty member or the university support center" resulted in 19% of the students disagreeing and 38% of them answered that they were neutral. Even though keeping the course functioning and providing support when necessary is the last step in the framework, it is by no means less important than the actual design and development of the course. The importance of the Support Structure and the feedback of users should be taken into consideration in any online medium.

Interaction

One of the biggest debates of the online education community is whether the level of interaction in a traditional, face-to-face classroom can be captured during an online course. Blackboard has many useful tools - such as Discussion Boards, Groups Tool and Chat, among others - designed to ensure that the students interact with each other. The results of the survey also show that the students are aware of this and support this. 44% of the students have agreed that different tools encourage and enhance communication with classmates, while 19% of the students strongly agree. Incorporating these tools since the beginning of the design phase, especially during conceptual design, will also ensure that the course material is modified in a way that will allow for more interaction.

In order to gain a complete understanding of the efficiency and effectiveness of the online course design, results that indicate a negative attitude should also be analyzed. The number of students who had a negative attitude with online courses fall on the lower side; for the results to be more

visible, the answers for "Disagree" and "Strongly Disagree" have been merged, and the following results have been obtained: Ease of use, Supportability and Communication emerge as areas that need more attention and improvement. Three students (approximately 19%) noted a negative attitude towards technical problems being solved quickly by the faculty member or the university support center. The same percentage of students has also stated that they could not easily find the documents or course material they needed.

These issues may be due to certain features of Blackboard, or the course design itself. A previous version of another online course tool, WebCT, carried the option of letting students know when there was new material posted. Currently, Blackboard does not have this automatic feature. In issues such as this, the responsibility falls on the instructor to guide the students in each step. However, it is the students' responsibility to check Blackboard regularly and get familiar with the different features. 19% of students have also noted that different tools in Blackboard, such as Discussion Boards, Groups, etc. have not encouraged and enhanced communication with classmates. This is an issue highly dependent on the nature of the course, and of the students. Setting up and using different interaction features of Blackboard should be incorporated into the design or the online course, and students should be encouraged to use these tools. In some instances, a portion of the final grade can be allocated to use of Discussion Boards for instance, which may provide more encouragement to the students to use these tools. 12% of students have stated that they do not wish to take more online courses in the future. This is an indication of how important course design and development is.

CONCLUSION

Online programs have become an integral part of education, therefore it is important to focus on the efficiency and effectiveness of online courses that are being offered. The design, development and delivery of an online course has many implications for different stakeholders; effective learning for students, effective teaching for instructors, financial and strategic consequences for institutions, and employing qualified professionals for industry partners, among others. The systems engineering-based framework described in this paper is intended to provide academicians with an effective and rigorous approach to design, develop and deliver online courses.

The significance and utility of the developed framework is twofold: Repeatability and transferability. Usually, faculty members are required to develop an online course every semester, as well as teaching face-to-face courses. Having a framework to assist them in each online course will not only be helpful, but also ensure consistency in the online course design and delivery. The generalizability

of the framework makes it easier to transfer from one course to another or from one discipline to another. The SysEF framework can be used for a business course, just as it is used here for an engineering management course, since it is context-free. Issues such as user requirements identification and feasibility analysis, for instance, are valid for all disciplines. One additional research topics that stemmed out of this research was the application and value of the framework, which was evaluated through a survey distributed to students who have taken the course that was developed by using the SysEF. Using the framework to guide the transition of a face-to-face class to an online class supports the utility and highlights the value of the framework.

The survey conducted in this study was used to evaluate the online course that was developed by using the framework. The success (or failure) of the online course is taken as a proxy variable for the efficiency of the framework. The students were the main stakeholders of this course as users, therefore they represent an accurate population that could evaluate whether the framework was successful or not; i.e. their opinions on the online course. Continuation of this study in the future may include further (and direct) assessments of the framework through data collection; especially by increasing the sample size and expanding the population to faculty members who are willing to apply the SysEF in their online course design and development. Systems engineering experts can also be consulted as to whether the framework should be, and can be modified to include more steps to ensure efficiency. It is hoped that these studies will lead to continuous modification and improvement of the SysEF framework.

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