AC 2012-4471: UTILIZING THE ENGINEERING DESIGN PROCESS TO CREATE A FRAMEWORK FOR CURRICULA DESIGN

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Utilizing the Engineering Design Process to Create a Framework for Curricula Design

Abstract

Project-based…inquiry-driven…student-centered…all keywords found when reading literature about techniques used in the engineering classroom. It is clear there is a large community of engineering educators that feels these techniques need to be integrated in the classroom. Research has shown that these pedagogies create an environment that is more engaging to the students. However, a possible downfall of these techniques is that they can become time consuming and if not integrated properly can become the focus of a course taking away from learning the fundamentals.

Engineering educators can "fit a project in" on a micro level by the addition of new techniques periodically in class. On the macro level, the question is how one can create a complete overhaul of a particular curriculum while maintaining the integrity of the content. To answer this question we look to the engineering design process. The same principles of engineering design can be applied to curriculum design. The engineering educator has a product – the course – and is told to make it better for the consumer – the students.

This paper will present a framework that describes in detail the engineering design process and how it relates to each step of our curriculum design process. Because of the active research methodology, examples from curriculum redesigns that were used to help develop this model of curriculum design will be highlighted. This innovative approach on the curriculum design process for engineering education will be discussed in detail.

Introduction

Engineering Educators, for years, have been trying to improve the education process for engineering students. The goal of the educator is to create a classroom environment that is more engaging and promotes transfer in the students' learning. Success in teaching for transfer is shown by students not only learning a concept in an isolated instance but rather being able to take what they learn and transfer it to other applications. The National Research Council for psychology has identified some essential concepts for both the teacher and learner in order to encourage deep understanding and the ability to transfer. The concepts identified by the council are (a) learning the fundamentals is key, (b) too much context could be harmful and instead some abstraction could promote better transfer, (c) maintaining a level of excitement and engagement leads to deeper understanding, and (d) instructors should keep in mind that learning new concepts builds on previously learned concepts when developing a course[1]. Engineering Educators strive to create environments that promote learning on a deep level in engineering classrooms. Many papers have been written by engineering educators with the concepts identified by the National Research Council as their underlying themes[2, 3, 4]. Engineering Educators understand the need for students to transfer their knowledge of a concept from one class to another. Many of the courses in an engineering curriculum build on one another. If a student does not have a deep understanding at the beginning, it will be hard for them to succeed in the future.

It is one thing to understand the attributes needed for deep learning, but engineering educators must take action to put these concepts into practice in the engineering learning environment. In many cases, action has been taken where curriculum that promotes engagement and deep learning is available to a certain extent. Instructors have taken current content in a curriculum and added projects that illustrate the content. Some classes are completely redesigned to have these engaging techniques, but in other cases projects are added as an afterthought. Simply putting in a project to aid in discussion of a concept is fine and has its merits; however, poor implementation of the project will detract from the fundamental concept being taught. Additionally, some of the projects or engaging techniques are implemented, but only reach a surface level of understanding for the students and in turn deep learning is not achieved.

As discussed above, simply plugging in a project here and there whenever it fits appropriately can provide benefits to the students, but, if a course is examined as a whole and redesigned, a more seamless integration of fundamental concepts with projects can be achieved. The question is, however, how can one perform a complete overhaul of a particular curriculum while maintaining the integrity of the content. For engineering educators, it seems only fitting to look towards the engineering design process. The same principles of engineering design can be applied to curriculum design. The engineering educator has a product – the course – and is told to make it better for the consumer – the students.

Engineering Design Process

Throughout the years there have been many models created that illustrate the engineering design process; a few of which are shown in Figures 1, 2, and 3.

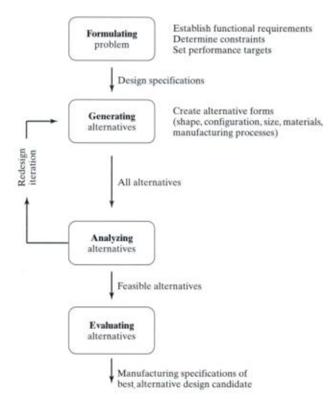

Figure 1. A graphic depicting the Engineering Design Process[5]

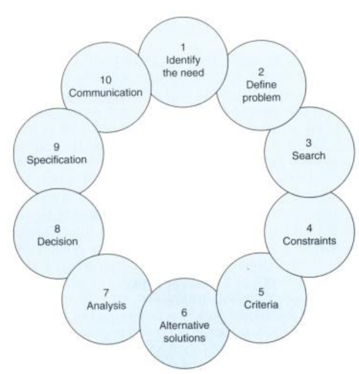

Figure 2. A Graphic Depicting the Engineering Design Process[6]

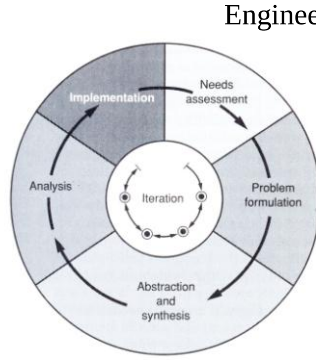

Figure 3. A graphic depicting the Engineering Design Process[7]

The steps in each figure vary slightly, but can all be condensed into four steps of design, each containing various sub-steps: Problem Formulation, Solution Generation, Solution Analysis, and Solution Evaluation. A closer look at each step is necessary in understanding the process as a whole.

The Problem Formulation phase is arguably the most critical stage in the engineering design process. To begin a design process full understanding the scope of a problem is needed to develop the most optimum solution. This is achieved by clearly defining all parameters and aspects of the problem through discussion with experts and previously conducted research; thus, time should be allotted to the definition of the problem statement. A clearly composed statement is needed in order to develop a solution. All aspects must be considered in the Problem Formulation stage. Understanding what is desired as the end goal as well as looking at the various parameters that might influence the end result such as: time, space, funding, materials available, etc. Keeping these parameters in mind will help in narrowing down the core of the problem statement.

In the Solution Generation phase of the design process the design team must develop potential solutions to the problem statement. The generation process can be done in a number of ways. One of the most popular methods used in today's engineering design is brainstorming. An individual or team generates a list of all possible solutions that could yield success in solving the problem statement. The list should be all inclusive having no restriction on what is proposed. The generation phase should allow for the most ridiculous to the most practical of solutions. Allowing for creativity in solution generation can potentially spark solutions that may not have necessarily been thought of due to restrictions on creativity. Many times the more outrageous solutions do not get implemented, but the outrageous may lead to creatively discovering a solution that solves the problem.

The Solution Analysis stage begins to take a closer look at the solutions developed in the generation phase. The design team must should look at each solution and analyze its feasibility for implementation and how well this will solve the problem. All parameters as they relate to the problem statement should be examined. For instance, the product being designed might have time constraints. This constraint should be taken into account when narrowing down the list of potential design solutions. Additionally, a comparison of the solutions generated is necessary. Comparing and contrasting solution A with solution B with solution C (and so on), can lead to determining which is the most appropriate solution. In the Solution Analysis phase, the design team might find that a combination of solutions is optimum. Analyzing each portion of the solutions and finding the most useful parts could combine into the best possible solution. Once the solution is narrowed down a prototype should be made of the best solution. The prototype can be analyzed further to determine how favorably the solution solves the problem. Much time should be spent in the testing of the prototype to ensure the design is optimum.

The fourth step in the engineering design process is the Solution Evaluation phase. Within this phase of the design process the prototype is developed into its final design. The final design is given to the customer for use. Feedback should be obtained from the customer such that future iterations of the design can be made with the necessary improvements.

Throughout these four phases of the design process the design team must keep in mind that design is not a linear process, it is rather an iterative process. While in the solution generation phase, the design team might determine that a closer look at the problem formation is necessary; thus, requiring the team to go back to stage one of the design process. For instance, another parameter might develop that changes the problem. During the Solution Evaluation phase the results might not lead to the desired solution and a look back at the Solution Analysis phase might be needed. Additionally, as mentioned with the final design feedback can be received that suggests changes should be made to the design, which leads the team back to the prototyping phase in the design process.

There are many techniques that are used in order to approach the design process. One in particular that is popular is the IDEO design philosophy[8, 9]. IDEO is a successful design firm that does consulting for various design projects. The company takes a humanistic approach to innovation by using diverse design teams to develop products. To begin the design process, the design team collects information on the product by reading research and talking to experts. Once adequate information is gathered, the design group begins the Solution Generation phase. The IDEO philosophy of design is heavily geared toward the brainstorming process. Brainstorming sessions are typically very comprehensive and abide by IDEO's five rules of brainstorming as established by IDEO: 1. Defer judgment, 2. Build on the ideas of others, 3. One conversation at a time, 4. Stay focused on the topic, and 5. Encourage wild ideas[8,9]. A facilitator is used to guide the brainstorming sessions, keeping the team on task and encouraging creativity while discouraging negativity. These intense brainstorming sessions are called Deep Dives[8], where the group dives deep into the design process generating a list of innovative ideas. Once brainstorming is complete, the group looks at the suggested ideas and decides together which ones are best suited for solving the design issue. If able they make mock up of a few designs or they try to take the best components of each design idea to create one optimum solution. A prototype is then constructed and tested, Solution Analysis phase. Various testing is performed on the prototypes, which leads to the final design that is given to the client or customers. Many engineering firms as well as engineering educators use the IDEO design process as a model for their own success in creating, innovating, and or course designing.

Curriculum Design Process

In order to design or even re-design a curriculum there are many aspects that must be looked out. What level of instruction is this curriculum (i.e. Elementary, Secondary, High Education, etc)? What are the standards the course must abide by? How in depth should the curriculum be written (i.e. lesson plans, instructor notes, student materials)? What material should be included in the course? How should interactive components be woven into the curriculum? What affect does the pedagogy associated with the curriculum have on the students? These are just a few examples of questions that need to be addressed when designing or redesigning a course. Once the key questions are addressed the curriculum development team can look more into the specifics of what is needed in the course and begin generating ideas of how the course should be designed. The curriculum design team then generates a new or revised curriculum for piloting and analyzing, which can be evolved into the final curriculum.

Relating Curriculum Design to Engineering Design

As you can see the four main steps in the engineering design process can be analogously linked with the steps in the curriculum design process. Looking more closely at the design of curriculum as it relates to engineering design can be useful in creating an end result that is optimum. In engineering a firm makes a product for customer use. This scenario can be related to curriculum design. Educators (the firm) present curriculum (the product) for the students (customers) to learn. The engineering firm wants to make their product better for their customers. Engineering educators want to make the curriculum better for students to understand. Engineering educators want students to have deep understanding and gain the ability to learn for transfer, thus engaging pedagogies are desired to make curriculum a better product for the "customers." Figure 4 shows a parallel comparison of the curriculum design process with the engineering design process.

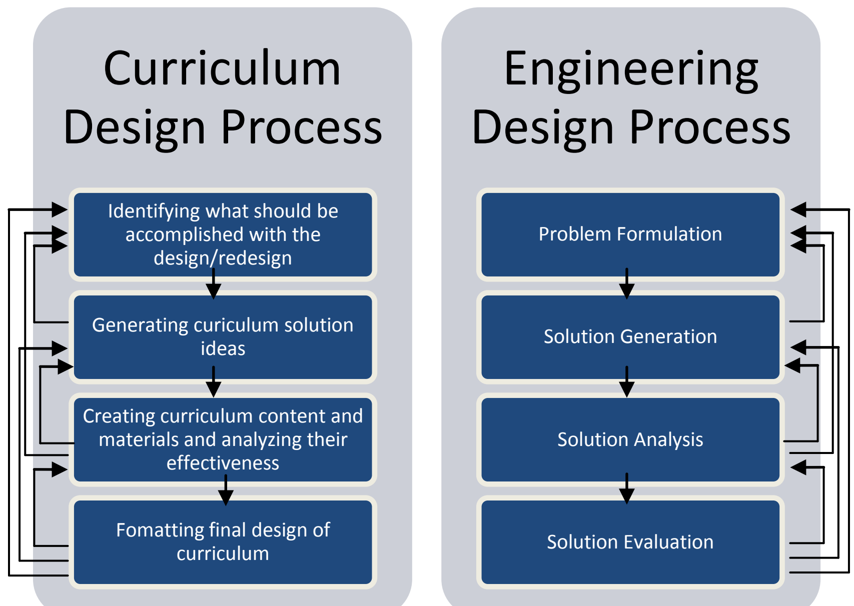

Figure 4. Parallel representation of the curriculum design process and the engineering design process.

In order to develop an innovative approach to curriculum that includes all the aspects of engagement needed for deep learning, educators must develop a clear understanding of the goal for the curriculum design. This process relates to the Problem Formulation stage of engineering design. All aspects of the purpose for the curriculum design, the manner by which it should be presented, and the students need for the content should be assessed when formulating the problem statement. Obviously, the fact that the curriculum needs to be redesigned (or designed for the first time) is the governing problem. However, the engineering educator must look at aspects such as: presentation of the material, type of pedagogy used for the curriculum, depth of material development, time allotted to teach curriculum, age of students, etc.

The second step in engineering design is Solution Generation. Similarly in curriculum design the second step is creating curriculum ideas. This phase includes brainstorming of curriculum content. Keeping in mind the goal is to better provide the product (the curriculum) to the customers (students). The educator must maintain a level of rigor such that the fundamentals are the basis of the content, while also providing applications that are relevant to the students. Brainstorming with the design team is essential in creating the most innovative approach to the curriculum. The design team should determine the fundamental concepts that are taught in the course. If the fundamentals are not known, (i.e. a state or national standard) a brainstorming session should be conducted to develop the fundamentals. Once the fundamentals are narrowed, the design team should brain storm active learning components that will enhance the learning experience for a given fundamental. Many ideas for each fundamental will be generated at this stage. Additionally the design team at this stage should brainstorm ideas for compiling the curriculum content and the form the curriculum will take in disseminating the new curriculum to the instructors of the course as well as the students (i.e. a book of notes, online curriculum, textbook, etc).

After adequate brainstorming time, the curriculum design process transitions into creating the curriculum prototype and testing the prototype or in terms of the engineering design process the Solution Analysis phase. This phase narrows the solutions generated by the previous stage and begins to formulate a solution to the problem. As this relates to engineering design a solution is developed by choosing the best design or combing the best aspects of designs to create a prototype product. In curriculum design, the design team will take the best ideas generated in the previous stage to create a layout or curriculum topics, projects/applications, and method of documenting the curriculum, essentially creating a prototype curriculum. This prototype would include the timeline for the curriculum as well as documented version of the projects and if needed instructor notes, lesson plans, and student materials. Much like engineering design this process is iterative and the initial flow of topics might be reassessed and changed during the testing of the prototype. Similarly some of the projects used to drive the fundamental concepts might need adjustment. This process for testing the curriculum is completed through a pilot phase of the course. The curriculum is taught in controlled environments feedback from both the instructor and the students is used to assess the accuracy of the curriculum design and its effectiveness of solving the problem as stated in the Problem Formulation stage.

Once the pilot phase is complete, the final design of the curriculum is ready to be presented to more "customers" (students). It is necessary to note that the pilot phase can be executed one time or twelve; it is up to the design team to determine how long the pilot phase should last before transition to the final design. The final design should be a modified version of the prototype with adjustments made from results of the testing process during the Solution Analysis phase. The term final design is somewhat misleading in that in many cases in engineering design you never truly reach a final design. Products in general always have room for improvement. This is also true with curriculum design. With changing attitudes towards topics as well as new technologies and pedagogical techniques, improvements can always be made. Which leads to the discussion that curriculum design just like engineering design is an iterative process. Inside each phase the design team may need to revisit an earlier phase in order to achieve the best results.

In design, both engineering and curriculum, typically the process is done in groups. This is necessary in order to gain a variety of perspectives and talents For instance, if an engineering company wants to develop a new ergonomic chair, should the team be made solely of the mechanical engineers at the firm, or rather should the design team be consisted of a diverse group of mechanical engineers, industrial engineers, salespersons, and human resources persons? The IDEO philosophy, discussed previously, chooses the latter[8, 9]. Additionally research has shown that diversity within a group is beneficial to the innovation level of the design[10]. Keeping this research in mind, the same approach should be taken with curriculum design. Hypothetically, educators might be tasked with redesigning a mathematics course for college level instruction. The curriculum design team for this course should not only consist of mathematicians, but also include instructors from other disciplines, such as engineering instructors and physics instructors. It might also be beneficial to the curriculum design to include a non-math oriented instructor like a history professor to gain additional perspective.

High School Physics Curriculum

An example of using engineering design to approach curriculum design was conducted at _______ University. Engineering faculty was tasked with redesigning a physics curriculum on the high school level by making it a more hands on and project-based. The project leader, a mechanical engineering faculty member, approached the design task with the IDEO philosophy in mind[9]. Knowing that a diverse team is ideal for design[10], the leader assembled a group consisting of four mechanical engineering faculty members, one electrical engineering faculty member, one mathematics faculty member, one graduate student in engineering education, and three high school physics teachers. This diverse group leant itself to many different perspectives towards the curriculum. The high school teachers were able to educate the university faculty on the needs of the instructor as well as the high school student. The faculty members were able to compose the necessary content of the course while giving the curriculum an engineering context.

Continuing with the IDEO process as a model for the curriculum design, the team met to assess the true goal of the curriculum redesign. The team researched various pedagogies, as well as current physics curriculum instructional techniques. The team had lengthy discussions in order to determine the full scope of the design project, including how the content should be developed and distributed to teachers, what topics should be presented, as well as how the course is designed in respect to the students needs. Ultimately the team decided that the course should be stand alone curriculum not dependent on a textbook, but rather the design team would create a set of instructor and student notes that would replace the textbook. In addition to the format of the materials, the problem statement also included the pedagogical approach to the course – fundamentals based course which is driven by the various projects. The team also decided with the problem statement that the course should use a microcontroller based platform for instruction. Identifying the use of the microcontroller at this stage helped in brainstorming the various projects associated with the curriculum. The team also felt that using the microcontroller technology would act as a hook for the students to increase their interest in the material. During the Problem Formulation phase the name of the course was coined, NASA-Threads, after the funding sponsor, NASA, and the threads of fundamental concepts and projects that would be woven together throughout the course[11].

Next the Deep Dive, as IDEO calls it, was conducted by the team. Key fundamental concepts for a physics course were identified and written on a white board. Each main concept was broken down into sub-concepts. The team, then, individually and collectively wrote on sticky notes ideas for projects related to the concepts and posted on the board. This session yielded many ideas for projects.

After the brainstorming process was complete the team had a diverse grouping of topics, concepts, and projects for the new curriculum. It was time for the Solution Analysis phase where the projects were narrowed down and further developed. At this point the team decided on the flow of material. Knowing that many of the projects would have to deal with the microcontroller the team decided to take a nontraditional route and start the physics course with the electricity and magnetism unit as opposed to most typical physics courses in high school that begin with work and mechanics. Starting with electricity and magnetism would provide the necessary background for the students to understand how the microcontroller works. After the electricity and magnetism section the course could easily transition into work and mechanics. After learning about electrical power through measurement the students could make the transition to mechanical power, an observed quantity, more easily. The team knew that servos connected to the microcontroller could make this transition more smoothly than a traditional physics curriculum could. After the work and mechanics unit the team places the light and optics unit followed by the waves and sound unit. After deciding on the flow of topics for the curriculum, the team assigned groups different units to develop. Developing the units was the key component for creating the prototype of the course. Each sub-team created lesson plans and instructor notes for the fundamental concept and the projects in the unit. The instructor notes contained complete descriptions of the concepts, example problems, suggested homework problems, in addition to project instructions. Once all the units were fully developed the team compiled all the lesson plans and instructor notes. A student worker was used to create student version of the notes. The prototype was complete and ready for testing. The curriculum was uploaded to a website developed specifically for the course. Teachers and students were able to access their material through the site. Initially the curriculum was tested by the three high school teachers on the design team, each of which were taught at three different high schools in the region; this allowed for a pilot year. In this initial year, the design team obtained constant feedback from the three instructors on adjustments needed for the curriculum before a full roll out[1 1].

After the pilot year, necessary changes were made to the curriculum which was then used by 15 different regional high schools. Throughout the second year roll out, feedback was still collected in order to make improvements to the course. This is shown in the engineering design process through its iterative manner. The course will never truly be complete because there is always room for improvement, new technologies and new project ideas. Following the second year roll out of the course additional schools were added to the third year implementation of the curriculum.

In order to present a new curriculum to instructors that typically teach a course in a different manner, introduction to the new curriculum was needed. This could be done in various manners like workshops, seminars/discussion sessions, consulting, mentoring/partner arrangements, and learning communities. As discussed in the literature, each method of professional development has its pros and cons. The best method is dependent upon the group of people the professional development is geared towards and the material being presented[12]**.**

For the NASA-Threads curriculum, years two and three were preceded by a professional development workshop for the high school teachers that would be teaching the new curriculum. A workshop was decided upon due to the need of addressing the many projects associated with the curriculum. The workshops were approached in an interactive manner such that the teachers would experience a fast paced version of the course within in a two week workshop period. Each school was asked to send the physics instructor as well as an addition instructor for support throughout the workshop as well as throughout the school year. At the workshop, the curriculum design team presented topics and projects from the curriculum. The workshop participants were tasked with learning the microcontroller platform as well as most of the projects in the course. This proved to be a rigors process; however, it allowed the teachers to experience the curriculum through the eyes of their students. This experience helped the teachers in understanding the student perspective of the course.

Survey
Throughout the workshop surveys were given to the participants to assess the effectiveness of the workshop. Below are results from the surveys given during the first year of the workshops. These results were used to assess the effectiveness of the workshop in conveying the new curriculum design to the teachers. The results were also used to make improvements for the following years' workshop. This dissemination of the curriculum content to the instructors is a key aspect in design process because the high school teachers are the vessels that transfer the product (course material) to the intended customers (students). Thus, making certain the workshops are effective is important to the design team.

Generally the responses to the survey questions were answered in a neutral or positive manner. However, one person did answer all questions in a negative manner. This is shown in Table 1, Table 2, and Table 3. Table 1is the workshop participants' responses to questions associated with the content of the NASA-threads curriculum that was presented during the workshop. Having the majority or participants respond positively towards the content helped to validate the new curriculum. It was clear reading through the open ended responses that the material presented a level of rigor that the students and the teachers for that matter are not accustomed to. They did, however, feel that it was in their students' ability to step up to the rigor and succeed in the course. Table 2 identifies workshop participants feeling towards the presenters of the workshop. Evaluating the presenters at the workshop was not a means to single out a certain presenter, but instead determine strengths and weakness to make the workshops better for future years. The positive responses and the answers from the open ended question all reveal that the presenters did a good job throughout the workshop. Table 3 identified the workshop participants' general feelings towards the workshop. In addition to the respondent that always answered negatively two of the questions had some respondents answer in the negative. The negative responses all dealt with pacing of the workshop. These responses helped in identifying pacing issues that could be adjusted in the future. Table 4 quantifies the open ended responses that participants gave when prompted to identify the most useful components of the workshop. For the most part the participants responded that working through the activities throughout the workshop was the most useful. Table 5 quantifies the open ended responses that participants gave when prompted to identify the least useful components of the workshop. Although many participants responded with "none," some participants had beneficial criticism. Many mentioned, again, issues related to pacing. They noted the workshop was sometimes too fast and other times to too slow.

Table 1. The workshop participants' responses to questions associated with the content of the NASA-threads curriculum that was presented during the workshop.

NASA Threads 2010 Summer Institute: Final Evaluation - Question 1							
For each of the following areas, please indicate your reaction to the following statement. The content delivered during the workshop session:							
Answer Options	**SD**	**D**	**U**	**S**	**SA**	**RA**	**RC**
A. is/will be applicable to my teaching	1	0	0	6	**16**	**4.57**	23
B. was well organized	1	0	2	6	14	4.39	23
C. practical to my needs	1	0	0	8	14	4.48	23

and interests							
D. was at the appropriate knowledge level	1	0	**3**	**10**	9	**4.13**	23
E. was connected to effective activities	1	0	0	6	**16**	**4.57**	23
F. was illustrated by/with useful visual aids and handouts	1	0	1	5	**16**	4.52	23
G. was at the appropriate skill level	1	0	2	7	13	4.35	23
Additional comments are welcome							5

Additional comments are welcome	
1	great session. The presenter was very very good
2	Some activities I felt were beyond the level of students that this will be affecting. Just remember that these are still high school students and not college students. There is a maturity level to consider.
3	This will be extremely helpful to me in my teaching this year. I am hopeful that this will increase the enrollment in physics at my school and also the number of students who elect STEM majors.
4	very helpful
5	It will take me some time to work through the math... I understand it, but am not used to explaining so many steps. However, it is well within me and my students' abilities.

Table 2. Identifies the workshop participants feeling towards the presenters of the workshop.

NASA Threads 2010 Summer Institute: Final Evaluation - Question 2							
For each of the following areas, please indicate your reaction to the following statement. The instructors/presenters:							
Answer Options	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Rating Average	Response Count
A. demonstrated thorough knowledge of the workshop content	1	0	0	4	18	4.65	23
B. demonstrated enthusiasm for the workshop content	1	0	0	2	**20**	**4.74**	23
C. delivered the content in a clear and	1	0	**3**	**10**	9	4.13	23

understandable fashion							
D. responded effectively to questions	1	0	0	3	19	4.70	23
E. incorporated useful examples	1	0	0	5	17	4.61	23
F. modeled effective pedagogy	1	0	2	6	14	4.39	23
G. created a positive learning environment	1	0	0	3	19	4.70	23
Additional comments are welcome							5

Additional comments are welcome	
1	All of the Tech staff were great
2	some instructors were clearer than others
3	they are awesome!!!!!
4	great instructors
5	All instructors were great - understandable and enthusiastic.

Table 3. Identifies the workshop participants feeling towards the workshop in general.

NASA Threads 2010 Summer Institute: Final Evaluation - Question 3							
For each of the following areas, please indicate your reaction to the following statement. The workshop:							
Answer Options	**Strongly Disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly Agree**	**Rating Average**	**Response Count**
A. was well organized and followed a logical order	1	0	2	7	13	4.35	23
B. met the proposed objectives/outcomes	1	0	1	8	13	4.39	23
C. had a positive effect on your knowledge of the workshop content	1	0	0	6	16	4.57	23
D. provided satisfactory food, snacks, and beverages	1	0	1	6	15	4.48	23
E. had a positive effect on your confidence in teaching the workshop	1	0	1	7	14	4.43	23

content							
F. facilities were appropriate and satisfactory	1	0	0	6	16	4.57	23
G. had a positive effect on your enthusiasm for teaching the workshop content	1	0	0	7	15	4.52	23
H. was paced appropriately	1	**3**	1	**11**	7	3.87	23
I. had efficient and informative pre-workshop administration	1	0	**2**	8	12	4.30	23
J. had appropriate time allocated to presentations and interactive group work (activities)	1	2	1	8	11	4.13	23
K. was a valuable learning experience	1	0	0	4	**18**	**4.65**	23
Additional comments are welcome							3

Additional comments are welcome	
1	Hospitality was great!
2	I love the integrated approach....ME's teaching electronics, etc. What a great group of colleagues who obviously like working together to improve the process!
3	It would have been nice if one week had been at the end of June and the other week at the end of July. The last week of July is too close to the start of school.

Table 4. Identifies what the aspects of the workshop that participants felt was most useful.

NASA Threads 2010 Summer Institute: Final Evaluation - Question 4		
Which element(s) of the Summer Institute was the most useful? Please explain your response.		
Number		**Response Text**
1		The activities.

2		all were useful
3		All of the activities.
4		The overall organization and activities presented at the institute were effective in teaching us how to integrate this curriculum in our classroom.
5		Working through activities to gain some experience with hardware and software.
6		all of the activities will be great in the classroom
7		Boe Bot instruction. Execution and management of projects.
8		The projects helped me see what my students may encounter during the year.
9		The hands on projects were the most useful. It is the area that I will have the most trouble with.
10		The activities really opened my eyes to more ways to incorporate project based learning.
11		Great workshop
12		The vast content that was presented.
13		The hands on activities
14		Group work and doing the activities together. This should be very helpful once school starts.
15		Working through the projects
16		The commitment to project based learning and the chance design and build solutions to problems - the students will be highly motivated!
17		I anticipate using everything that was presented - not quite sure how or when yet. May also use some modified activities in my Intro to Engineering class. I needed the instruction and introduction to programming and Excel.
18		exposure to the program and refreshing my knowledge base.
19		I have been exposed to presenting the old concepts with new ways by using technology.
20		hands on activities
21		doing the activities was most useful, seeing what should happen and what could go wrong
22		Using technology and Excel

23		I believe that the activities and the analysis were valuable and useful.

Table 5. Identifies what the aspects of the workshop that participants felt was least useful.

NASA Threads 2010 Summer Institute: Final Evaluation -Question 5		
Which element(s) of the Summer Institute was the least useful? Please explain your response.		
Number		**Response Text**
1		None.
2		all were useful
3		Some of the lectures.
4		The theory discussions were helpful, yet very dry and boring.
5		None
6		it was all useful, a touch heavy on spread-sheeting
7		Doing problems.
8		I wish I could have seen the master notes and handouts at the same time as the project/concepts were discussed so I could compare what we are given to what we need to know.
9		none
10		The original excel lessons were not beneficial to me personally. However, the excel lessons later were far more developed and in-depth and taught me things I never knew
11		n/a
12		nothing
13		Some lectures I felt were beyond the appropriate level.
14		None.
15		None
16		To help the teachers follow along with the Tech professor guiding us through a lesson, I the teachers be given an itinerary for the week that states which lessons will be covered so that they can read over the master notes beforehand.
17		Right now I think I will be able to use everything but since I am not experienced in this, I don't know.
18		sometimes a little too much too fast and others times there was too much down time. Work on pacing of activities.

19		I would prefer this workshop to be planned at least a month long.
20		more explanation of the physic/math
21		Some breaks could perhaps be shortened a little in order to end earlier in the evenings.
22		none
23		n/a

Conclusion

Many engineering educators strive to improve the quality of the curriculum that is presented to the students. Ultimately engineering educators want to teach curriculum that provides a deep level of understanding and learning for transfer by the students in the course. Engaging students in the classroom has been shown to provide this level of understanding. Engineering educators must understand how to best employ the engaging techniques in the curriculum such that the fundamentals are not lost in the projects. A framework for curriculum design is essential to understand how best to incorporate these engaging pedagogies. Since the process of integrating new projects and technologies into the classroom requires design. Engineering educators can turn to the engineering design process in order to accomplish the task of curriculum design. The procedures of engineering design and curriculum design can be approached such that the curriculum design process mirrors the engineering design process. Through experimentation, this framework has been tested and a new high school physics curriculum was developed. Further analysis of the framework of curriculum design using an engineering design basis is necessary to assess the effectiveness of taking such an approach.

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