Implementing Entrepreneurial Mindset Learning (EML) in a Timber Design Course

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Abstract

Timber design is a technical elective course for junior and senior civil engineering students at Ohio Northern University. To help students apply the concepts learned in this course and previous courses such as Strength of Materials and Structural Analysis to the real-world applications as well as improve their entrepreneurial mindset per Kern Entrepreneurial Engineering Network (KEEN) learning objectives, a comprehensive half a semester-long project was developed. The paper describes the project, where students were required to form a team/company of four to five members, create Auto CAD drawings for their dream houses, determine the loading, utilize a professional software such as WoodWorks to design the common elements of the building, and select one layout as a superior design using the Need-Approach-Benefits-Competition (NABC) framework. It was found that students enjoyed the real-world aspect of the project, the freedom to create the layout of their buildings, and applying all the knowledge learned in the class and previous courses.

Introduction

Project-based learning (PjBL) has been widely used in engineering education. Several studies have shown the effectiveness of PjBL in terms of increasing understanding, motivating students, taking ownership, and helping to bridge the gap between the classroom and workplace by preparing students with skills such as leadership, team building, critical thinking, and problem solving [1, 2]. In this methodology, an assignment with multiple tasks is normally used to drive the students learning activities to produce a final product in the form of a design, model, and device or service that can be utilized in real world. PjBL is similar to problem-based learning (PBL) in terms of involving teams of students in open-ended and challenging assignments, which resemble the real-world situations as well as identifying solutions and reevaluating their methodology. The difference between the two approaches is that the PjBL covers a broader scope and may include several problems. In addition, PjBL focuses on the final product by applying or integrating previous knowledge while the emphasis of PBL is on the acquisition of new knowledge [3].

Currently universities are utilizing entrepreneurial-minded learning (EML) as well. Through EML students get to solve a problem in a fashion that creates value, which helps to create engineers to make an impact in the workplace [4, 5]. EML course modulus can be created by incorporating behavioral or complementary skills into student-centered pedagogy. Examples of such skills are demonstrating constant curiosity, exploring a contrarian view of accepted solutions, assessing and managing risk, evaluating economic drivers, examining societal and individual needs, understanding the motivations and perspectives of others, conveying engineering solutions in economic terms, identifying an opportunity, investigating the market, evaluating customer value and economic viability, protecting intellectual property, and validating market interest. Particularly, EML builds upon active pedagogies such as PBL by integrating curiosity, identifying opportunity, and creating value [6]. It is important to understand that

entrepreneurship, in this context, is not necessarily about teaching students how to start a new business, but rather to develop the mindset of innovation necessary to recognize opportunities and make the most of them. EML is being promoted by Kern Entrepreneurship Education Network (KEEN) and implemented at many institutions. 3Cs of the entrepreneurial framework are defined as:

1. Curiosity. Students are encouraged to demonstrate constant curiosity about our world, and explore different solutions, which empowers them to investigate the rapidly changing world and motivates them to become life-long learners.
2. Make connections. Students integrate information from many sources to gain insight, assess, and reveal innovative solutions.
3. Creating value. Students get to create value by identifying unexpected opportunities and learning from failure to meet the needs of a changing world [6, 7, 8].

The current paper seeks to facilitate the transformation of a technical project into EML that increases the understanding of students of entrepreneurial thinking. Such implementation of entrepreneurially-minded project-based learning in timber design course is discussed in the paper. In addition, the project description, assessment criteria, observations of the instructor, and examples of student work are presented in the paper.

Project Description

Timber design course is offered as an elective course for junior and senior civil engineering students at Ohio Northern University. The students in the course learn how to design different members of a typical wood building through predefined problems and parameters. However, they may not necessarily understand the rational relationship between different elements in terms of load path and the design sequence. Therefore, it was felt that assigning an open-ended real-world project would be beneficial. The project was implemented during the spring semester of 2019. The learning objectives of the project were as follows:

- Connect content from previous courses such as Structural Analysis to determine design loads on typical wood-frame buildings, which is related to connections.
- Use a professional software such as WoodWorks to design beams, columns, and studs.
- Develop a propensity to ask more questions, which is attributed to curiosity.
- Create solutions through investigating different building layouts that meet stakeholders needs
- Craft a compelling value proposition tailored to specific stakeholders, which is attributed to curiosity as well as creating value.
- Meet commitments to the rules developed by the team and work with individuals with complementary skills sets, expertise, etc. to produce effective written reports and verbal presentations.

Appendix 1 shows the description of the project. Following Hurricane Michael in October 2018, many buildings were destroyed in the Florida Panhandle. The students in the timber design course, as experts in the design of wood buildings, were assigned a project to investigate different layouts of residential buildings as their dream houses to facilitate the recovery for hurricane survivors. This was used as a hook statement to increase the motivation of students to

take ownership of the project and identify the most cost effective, and constructible buildings. To keep the project more interesting and give students more freedom, they were asked to design their dream houses even though that may not necessarily be aligned with the needs of the hurricane survivors. However, the students had to meet the following design requirements:

- The buildings must be house, condo, apartment, or townhome.
- The buildings must be single- or two-story residential buildings.
- The square foot of the building must be at least 750 ft^2 but not exceed 2000 ft^2.
- Each building is to be designed for dead load, roof live load, live load, and wind load. The loads must be determined per ASCE 7 minimum design loads.
- The company must use DF-L sawn lumber, not incised. If necessary, use glulam; however, must justify such application.
- The following items must be designed for each building:
    - Roof framing members (typical purlin, beam, girder) or truss members.
    - Columns if any, must design at least one interior and one exterior column.
    - Load bearing interior and exterior wall studs
    - Roof/floor diaphragm and shear walls
- The company may use commercial software such as Tedds or WoodWorks for design.

The class consisted of 31 students. The students were asked to organize into groups of four to five by selecting their group members. Each group was to represent a fictitious startup company in order to bring their consulting service to the market. The students had to select a name for their company and list the set of the rules and expectations for the team. Examples of such rules are listed in Appendix 2. The purpose of the rules was effective team work and communication among group members as well as a reminder of how to avoid the common pitfalls. The students were not evaluated on adherence to their own rules.

Stimulating the curiosity of students is one of the most important goals of any educator. If successful, the student will be motivated to continue to learn and explore the course material outside of the classroom and find connections with other information or applications. To stimulate the curiosity of students, Question Formulation Technique (QFT) was utilized. The QFT enables students to generate technical questions, which makes the process of problem solving easier and helps them to take ownership of materials and become self-directed learners. It is important for a student to be aware of what they do not know and be able to articulate it in the form of a question [9]. Thus, each company was asked to submit a list of questions. The instructor served as the client. Samples of students questions are listed in Appendix 3. The questions were answered and returned to each group. In addition, common questions were discussed and elaborated in the class to avoid any confusion because the stakeholder or client feedback is essential to understand what is deemed as valuable. This was intended as a tool to encourage students to ask further questions, which was successfully achieved.

In addition, each company must pitch a written proposal to convince the client that the design is a suitable and cost-effective solution to the problem that is in some way unique and more advantageous than other companies. Each member of the team was required to investigate and design a unique layout of a residential building as their solution. Exploring multiple solutions further stimulates the curiosity of the students. The alternative designs were to be considered competing solutions to the problem. The selection of the final design should be based on Need-Approach-Benefits-Competition (NABC) approach. NABC framework developed by Stanford Research International to teach engineering students how to articulate value propositions. The NABC framework starts with a clear articulation of underlying Need the idea addresses. Then, the Approach to meet the need is described. The Benefits of the approach to the specific stakeholders must be highlighted and should demonstrate a favorable benefit to cost ratio. Finally, the Competition should be analyzed to show how the idea improves upon the competing solutions [10, 11]. In this project, Need was given with a well-defined problem. The Approach was suggested through project requirements. The Competition was limited by requiring students to design alternative viable solutions and using the alternative solutions as the Competition. Benefits were articulated through evaluation metrics considered in the design such as cost and constructability.

Direct Assessment

The following grading was used for the project:

1- Team charter- 5%: selection of a name for the company, listing the set of rules and expectations for the team, and submitting questions. Appendix 4 shows an example of the charter. Table 1 shows the evaluation rubric for team charter. 84% of students scored at least 90% and 16% scored 75% to 90%.

Table 1. Evaluation Rubrics for Team Charter

	Excellent	Above Avg.	Average	Marginal/Unsatisfactory	Pts
Number of Questions	**10 pts** At least 8 questions generated	**8-9 pts** Between 6 and 8 questions generated	**6-7 pts** Between 3 and 6 questions generated	**0-5 pts** Less than 3 questions generated	
Question Redundancy	**10 pts** No questions are redundant	**8-9 pts** There are at most a couple of redundant questions	**6-7 pts** There are several redundant questions	**0-5 pts** There are too many redundant questions	
Question Relevance	**10 pts** All questions are very relevant to the topic	**8-9 pts** All questions are mostly relevant to the topic	**6-7 pts** One or two questions are not that relevant to the topic	**0-5 pts** Most of questions are not that relevant to the topic.	
Spelling, Punctuation, & Grammar	**10 pts** Spelling, punctuation and grammar are all correct	**8-9 pts** There are at most a couple of errors in spelling, punctuation or grammar	**6-7 pts** There are several errors in spelling, punctuation or grammar	**0-5 pts** There are too many errors in spelling, punctuation or grammar	

2- Building layout- 10%: Each member of the team must investigate a unique layout and include AutoCAD drawings of architectural floor plan(s) and elevations of their building as well as the framing plan. Appendix 5 shows an example of the building layout. The evaluation rubric for the layout is shown in Table 2. 72% of students scored at least 90%, 16% between 75% and 90%, and 6% between 60% and 75% as well as below 60%.
3- Design Handbook- 60%: Each member must submit a design handbook that includes hand calculations and/or software results of their building. The evaluation rubrics for the design handbook is shown in Table 2. 26% scored at least 90%, 42% scored 75% to 90%, 26% between 60% and 75%, and 6% below 60%.
4- Written proposal- 5%: problem description, constraints, alternative solutions, analysis and design of each solution including hand calculations or software results, selection of superior design through NABC approach, AutoCAD drawings for the selected design, and conclusions. The proposal was assessed through evaluation rubrics. Table 3 illustrates the rubrics. 16% scored at least 90% and 42% scored 75% to 90% as well as 60% to 75%.
5- Peer evaluation- 5%: team members were asked to evaluate their peers through rubrics on different skills such as working with others, attitude, time management, quality of work, contributions, and problem solving. The students were asked to submit their peer evaluation twice, one in the middle and the other at the end of the project. Appendix 6 shows the rubrics. 90% scored at least 90% and 10% below 60%.
6- Presentation- 15%: each company was asked to prepare a 5- to 10- minute presentation on the constraints of the project, a review of alternative solutions, the superior design, and description of NABC approach for the superior design. The rubrics is shown in Table 4. 19% scored at least 90%, 68% between 75% and 90%, 10% between 60% and 75%, and 3% below 60%. Samples of student work for design handbook, written proposal, and presentation are presented through a KEEN card on the Engineeringunleashed.com platform [12].

Table 2. Evaluation Rubrics for Building Layout and Design Handbook

Content						
	Excellent	**Above Avg.**	**Average**	**Marginal**	**Unsatisfactory**	**Pts**
Dead Load	**10 pts** Thoroughly calculates load	**9-8 pts** Sufficiently calculates load with minimal errors	**7-6 pts** Reasonably calculates load with some errors	**5-4 pts** Poorly calculates load	**3-0 pts** Load calculations are missing or completely erroneous	
Roof Live/Live Load	**10 pts** Thoroughly calculates load	**9-8 pts** Sufficiently calculates load with minimal errors	**7-6 pts** Reasonably calculates load with some errors	**5-4 pts** Poorly calculates load	**3-0 pts** Load calculations are missing or completely erroneous	
Wind Load	**10 pts** Thoroughly calculates load	**9-8 pts** Sufficiently calculates load with minimal errors	**7-6 pts** Reasonably calculates load with some errors	**5-4 pts** Poorly calculates load	**3-0 pts** Load calculations are missing or completely erroneous	
AutoCAD Drawings	**10 pts** Thoroughly creates AutoCAD architectural drawings of the plan view and elevations and structural framing plan; shows all the dimensions and building components (doors, windows, living room, bed rooms, etc.).	**9-8 pts** Sufficiently creates AutoCAD architectural drawings of the plan view and elevations and structural framing plan; shows all of the components of the building, but missing one or two dimensions.	**7-6 pts** Reasonably creates AutoCAD architectural drawings of the plan view and elevations and structural framing plan. Some components and dimensions are missing.	**5-4 pts** Poorly creates AutoCAD architectural drawings of the plan view and elevations and structural framing plan. Most dimensions and components are missing. Some plans and elevations are missing.	**3-0 pts** AutoCAD drawings miss most plans or elevations; no AutoCAD drawings	
Typical Subpurlin Design	**10 pts** Thoroughly designs the element.	**9-8 pts** Sufficiently designs the element with minimal errors.	**7-6 pts** Reasonably designs the element with some errors.	**5-4 pts** poorly designs the element. One or two checks are missing.	**3-0 pts** No design or is completely erroneous.	
Typical Purlin / Joist Design	**10 pts** Thoroughly designs the element.	**9-8 pts** Sufficiently designs the element with minimal errors.	**7-6 pts** Reasonably designs the element with some errors.	**5-4 pts** poorly designs the element. One or two checks are missing.	**3-0 pts** No design or is completely erroneous.	
Typical Girder Design	**10 pts** Thoroughly designs the element.	**9-8 pts** Sufficiently designs the element with minimal errors.	**7-6 pts** Reasonably designs the element with some errors.	**5-4 pts** poorly designs the element. One or two checks are missing.	**3-0 pts** No design or is completely erroneous.	
Typical Wall Stud / Column Design	**10 pts** Thoroughly designs the element.	**9-8 pts** Sufficiently designs the element with minimal errors.	**7-6 pts** Reasonably designs the element with some errors.	**5-4 pts** poorly designs the element. One or two checks are missing.	**3-0 pts** No design or is completely erroneous.	

Table 3. Evaluation Rubrics for Written Proposal

Content						
	Excellent	**Above Avg.**	**Average**	**Marginal**	**Unsatisfactory**	**Pts**
Introduction & Problem Description	**5pts** Provides excellent high-level description of problem: project importance and client need well-defined	**4pts** Provides good high-level description of problem: project importance and client need defined	**3pts** Provides decent description of problem: some importance of the project and some aspects of the need established	**2pts** Missing high-level description of problem: project importance and client need minimally or poorly addressed	**1-0 pts** Missing high-level description of the problem: project importance and client need not addressed	
Constraints & Criteria	**5 pts** Clearly & concisely identifies important constraints and criteria	**4 pts** Clearly identifies some important constraints and criteria	**3 pts** Identifies some constraints and criteria	**2 pts** Lacks in constraints and criteria	**1-0 pts** Severely lacks in constraints and criteria	
Superior Design Selection	**10 pts** Expertly describes the need; expertly describes the design approach; expertly articulates the benefits per cost; thoroughly justifies superior design over design alternatives	**9-8 pts** Describes correctly the need; describes correctly the design approach; articulates the benefits of the solution based on criteria; sufficiently justifies superior design over design alternatives	**7-6 pts** Describes mostly the need; describes the design approach; articulates some benefits of the solution; somewhat justifies the superior design over alternatives	**5-4 pts** Misses the main ideas of the need; describes aspects of the design approach; missing some benefits of the solution; marginal justification of superior design over alternatives	**3-0 pts** Poor discussion of need, approach, benefits, no selection of superior design	
AutoCAD Drawings	**5 pts** Thoroughly creates AutoCAD architectural and structural drawings of the plan view for the superior design.	**4 pts** Sufficiently creates AutoCAD architectural and structural drawings of the plan view for the superior design.	**3 pts** Reasonably creates AutoCAD architectural and structural drawings of the plan view for the superior design.	**2 pts** Poorly creates AutoCAD architectural and structural drawings of the plan view for the superior design.	**1-0 pts** AutoCAD drawings miss details; no AutoCAD drawings	
Conclusions	**5 pts** Concise summary of problem & solution; insightful discussion of redesign/lessons	**4 pts** Good summary; good discussion of redesign/lessons	**3 pts** Decent summary; some mention of lessons and redesign ideas	**2 pts** Poor summary; little mention of lessons or redesign ideas	**1-0 pts** Poor or no summary; no mention of lessons or redesign	
Spelling & Punctuation	**4 pts** No spelling or punctuation mistakes	**3 pts** Few spelling or punctuation mistakes	**2 pts** Several spelling and/or punctuation mistakes	**1 pts** Frequent spelling and punctuation errors; incorrect capitalization	**0 pts** Spelling & punctuation interfere with understanding	
Paragraph Structure	**4 pts** Paragraph structure is strong and each paragraph flows well into the next	**3 pts** Paragraphs are generally limited to one idea, but not always well connected together	**2 pts** Paragraphs sometimes have unrelated ideas expressed and missing introductory & transitional sentences	**1 pts** Paragraphs often have unrelated ideas expressed and many missing introductory & transitional sentences	**0 pts** Report is NOT organized effectively into paragraphs	

Table 4. Evaluation Rubrics for Presentation

	Excellent	Good	Fair	Needs Improvement	Pts
Delivery	**5 pts** Holds attention of entire audience with the use of direct eye contact; speaks with fluctuation in volume and inflection	**4 pts** Consistent use of direct eye contact with audience; speaks with satisfactory variation of volume and inflection	**3 pts** Displays minimal eye contact with audience; speaks in uneven volume with little or no inflection	**0-2 pts** Holds no eye contact with audience; speaks in low volume and/or monotonous tone.	
Enthusiasm	**5 pts** Demonstrates a strong, positive feeling about topic during entire presentation	**4 pts** Shows some positive feelings about topic	**3 pts** Shows little or mixed feelings about the topic being presented	**0-2 pts** Shows no interest in topic presented	
Poise	**5 pts** Displays relaxed, self-confident nature about self, with no mistakes	**4 pts** Makes minor mistakes, but quickly recovers from them; displays little or no tension	**3 pts** Displays mild tension; has trouble recovering from mistakes	**0-2 pts** Tension and nervousness is obvious; has trouble recovering from mistakes	
Mechanics	**5 pts** Presentation has no misspellings or grammatical errors	**4 pts** Presentation has no more than two misspellings and/or grammatical errors	**3 pts** Presentation has three misspellings and/or grammatical errors	**0-2 pts** Presentation has four or more misspellings and/or grammatical errors	
Subject Knowledge	**10 pts** Demonstrates full knowledge by answering all questions with explanations and elaboration	**9-7 pts** Is at ease with expected answers to all questions, without elaboration	**6-4 pts** Is uncomfortable with information and is able to answer only rudimentary questions	**0 pts** Does not have grasp of information and cannot answer questions about subject	
Organization & Content	**15 pts** Thoroughly includes architectural and framing plans of the building; loading; design of a typical subpurlin, purlin or joist, girder, column, and stud; the superior architectural and framing plans; the selection procedure using NABC approach	**14-10 pts** Sufficiently includes architectural and framing plans of the building; loading; design of a typical subpurlin, purlin or joist, girder, column, and stud; the superior architectural and framing plans; the selection procedure using NABC approach. One item is missing	**9-6 pts** Two or three items of architectural and framing plans of the building; loading; design of a typical subpurlin, purlin or joist, girder, column, and stud; the superior architectural and framing plans; the selection procedure using NABC approach are missing	**0-5 pts** Poorly includes or severely lacks architectural and framing plans of the building; loading; design of a typical subpurlin, purlin or joist, girder, column, and stud; the superior architectural and framing plans; the selection procedure using NABC approach	

Discussion

An indirect assessment through an anonymous survey of the project was conducted by the instructor. The questions were selected based on the study by Gerhart and Melton to address both EML and technical dimensions [6]. 18 out of 31 students enrolled in the course submitted their responses. The survey asked students to rate each question on a scale of 1 (strongly disagree) to 5 (strongly agree). Table 5 shows the average of the results from the survey. For the entrepreneurial dimension, questions two, three, and six target creating value. Question 4 is related to curiosity and questions 1 and 5 target making connections. Questions 11 and 12 target the communications skills on the technical aspect of the project. Students overwhelmingly agreed that the project motivated them and gave them a better understanding of addressing customer's needs and using critical thinking skills to find solutions. Students found that they

improved a myriad of skills including design, load calculation, report writing, and overall communication, not only with each other, but with their client.

Table 5. Survey Results

Dimension	No	Survey Question	Average Rating
Entrepreneurial	1	The real-world application motivated me to do my best work	4.6
	2	Examined a customer's needs throughout the project	4.1
	3	Conveyed engineering solutions in economic terms throughout the project	3.9
	4	Applied critical thinking to ambiguous problems throughout the project	3.7
	5	Integrated information from many sources to gain insight throughout the project	3.6
	6	Created value for a customer or stakeholder throughout the project	3.3
Technical	7	Improved my skills in design of various elements of a framing plan	4.6
	8	Improved my skills in determining loadings	4.5
	9	Improved my skills in creating a framing plan that meets the design requirements	4.5
	10	Improved my skills in analyzing load path	4.2
	11	Improved my skills in producing effective written reports	3.9
	12	Improved my skills in reporting the solution to a customer	3.8

Figure 1 displays the relative frequency for each survey question. For question 1, 56% of students strongly agree and 44% agree that the real world application of the project motivated them. According to the results for survey question 2, over 85% of students agreed that they were able to examine the customer's needs throughout the project. 5% disagreed, but none strongly so. 28% of students strongly agreed and 39% agreed that they could conveyed engineering solutions in economic terms. One-third of students were neutral. Survey question 4 asked whether students applied critical thinking throughout the project. As shown in Figure 1, 11% strongly agreed, 56% agreed, 28% were neutral, and only 5% disagreed. More than half the students (55%) reported integrating information from many sources while 39% were neutral and only 6% disagreed. The project goal on creating value for a customer was somewhat successful as nearly half the students (45%: 6% strongly agreed and 39% agreed) agreed, one-third were neutral, and 22% disagreed. Students overwhelmingly (61% strongly agreed and 39% agreed) agreed that they improved their skills on designing various elements of a framing plan, question 7. The project successfully improved students' skills on both determining loads (question 8) and creating a framing plan (question 9) as 50% strongly agreed and 50% agreed. Based on the results for survey question 10, 28% strongly agreed and 67% agreed that the project gave them better understanding of load path. 5% were neutral and none disagreed. Questions 11 and 12 evaluated the communications skills. Over 70% agreed that the project successfully enhanced their skills on writing effective reports while less than one-third were neutral and none disagreed. Similarly, 22% strongly agreed and 44% agreed that the project helped them in reporting the solution to the customer. Less than one-third were neutral and 6% disagreed.

Figure 1- Relative Frequency for Each Survey Question

As seen in Table 5 and Figure 1, overall, the project was successful in targeting both technical and entrepreneurial skills of students and was well received by them. It is clear that students learned a lot from the project, however, they did not feel strongly that the project increased their skill in creating value. In author's opinion, creating value could be improved by making the hook statement stronger. One approach for clarifying the customers' needs and their value propositions would be to tighten the replacement home to a specific square footage and ask students to explore different value propositions and designs such as minimizing the construction time and cost and maximizing survivability during the hurricane. This may effectively establish a greater sense of connection to a customer's needs while recognizes that customers have varying priorities. In addition, material selection and designing all the elements of the buildings might give students a better idea of estimating cost since only one element (purlin/joint, girder, interior and exterior column, and stud) were designed over the course of the project.

The results also indicate that the students felt mostly comfortable in technical dimensions such as designing various elements, creating a framing plan, and determining the loads, which was in accordance with the direct assessment of their work. 29% of students scored at least 90%, 61% scored 70 to 90%, and 10% scored below 60% on the building layout and design handbook.

Based on the results of the open-ended feedback portion of the survey, students enjoyed the real-world application of the project and liked learning a new software. In addition, they enjoyed the freedom to create the layout of their buildings. It was noted that too many deliverables were due at the end of the semester. This might be overwhelming for the instructor to read and grade reports and calculations for a large class since each student submits a design handbook for their building. On the other hand, students asked for more time on the project. In author's opinion, since students are normally overwhelmed with other projects and exams at the end of the semester, the project must be assigned early and the deliverables should be broken down further into several milestones. In this manner, as a topic is covered in the class, students can work on the corresponding portion of the project and the instructor can provide them with feedback.

Summary and Conclusions

The paper describes an implementation of EML in a timber design course. The students were asked to design their dream house to facilitate the recovery of the hurricane survivors. Based on the feedback of students and observation of the instructor, the implementing project using the framework discussed herein can expose students to EML effectively. It should be noted that such EMLs could also be successfully used for other design courses.

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Appendix 1

Project Overview:
Students should organize into groups of four to five to design a residential building that is applied to the underlying design problem described below. Each group represents a fictitious startup company in order to bring their consulting service to the market. Each company must pitch a proposal in an effort to convince the client that the design is a suitable and cost-effective solution to the problem that is in some way unique and more advantageous than other companies.

Problem Description:
Hurricane Michael was the strongest hurricane in the Florida panhandle that made catastrophic damages due to the extreme winds in October 2018. Many homes were flattened or completely swept away by storm surge and high speed winds. To facilitate the recovery, ONU students in timber design class are to investigate and design different layouts of residential buildings. Each company needs to evaluate the layouts and identify the most affordable, cost effective, and constructible building.

Design Constraints/Requirements:

1- The buildings must be house, condo, apartment, or townhome.
2- The buildings must be single- or two-story residential buildings.
3- The square foot of the building must be at least 750 ft^2 but not exceed 2000 ft^2.
4- Each building is to be designed for dead load, roof live load, live load, and wind load. The loads must be determined per ASCE 7 minimum design loads.
5- The company must use DF-L sawn lumber, not incised. If necessary, use glulam; however, must justify such application.
6- The following items must be designed for each building:
    - Roof framing members (typical purlin, beam, girder) or truss members.
    - Columns if any, must design at least one interior and one exterior column.
    - Load bearing interior and exterior wall studs
    - Roof/floor diaphragm and shear walls
7- The company may use commercial software such as Tedds or WoodWorks for design.

Project Deliverables, Grading, and Due Dates:

1.) Team Charter (5%)

- Finalize your team members and select a name for your team/company. List the set of rules and expectations for your team. Some examples of rules may be proper preparation and attendance at group meetings, honest communication when conflicts arise, etc. Each team member must sign the sheet thereby indicating acceptance to comply with the rules and expectations. In addition, submit a list of questions related to this project that demonstrates your curiosity while express your interest in the project.
- Note: This set of rules and expectations is for your use and benefit. The instructor will make a copy and return it to you.
- **Due:** Wednesday, April 10, 2019

2.) Building Layout (10%)

- Each member of the company must investigate a different layout. The layout must be viable (i.e., meet the constraints set forth in the problem statement) and unique. If you are a company of four members, must have four different layouts. Each layout must include the plan of the floor(s) as well as the elevations of the building (north & south and east & west elevations). The architectural plan must include the location and dimension of bedroom(s), bathroom(s), living room, kitchen, etc. The elevations must include the location and dimension of the windows and doors. Framing plan, location of columns if any, and shear walls must be included in the structural plans. Create a full-scale drawing of plans and elevations in AutoCAD.
- **Due:** Wednesday, April 17, 2019

3.) Design Handbook (60%)

- Each member of the company is required to design their layout as a solution per design constraints set forth in the problem statement. It is required to submit loadings and hand calculations or software results for the design.
- **Due:** Monday, May 6, 2019.

4.) Written Proposal (5%)

- Producing alternative design solutions is a beneficial step in the engineering design process. For this project, your alternative designs will be considered competing solutions to the problem. The alternative design solutions must be compared through an evaluation metrics. The selection of the final design should be based on NABC approach and at least the following criteria: Cost and Ease of Construction.

  Each company must submit a written proposal. The written proposal should include the following:
  - **Introduction section** that motivates the underlying problem, briefly describes the approach to the solution.
  - **Problem Description section** that describes the problem and identifies the design constraints and evaluation metrics.
  - **Alternative Solutions and Analysis section** that should describe each design alternative, the approach to advocate for the superior design alternative, and the selected design. Use NABC approach to advocate for the selected design. The approach should be emphasized, as well as the benefits per cost compared to the superior design alternatives. It is also necessary to clearly restate the underlying need and identify based on the evaluation metrics why the preferred design is selected.
  - **Conclusion section** that briefly summarizes the problem and the selected design. Summarize the critical aspects of the approach and benefits that make it (the superior solution) better than the alternative. Describe the lessons learned from the project.
- **Due:** Monday, May 6, 2019.

5.) Peer Evaluation (5%)

Two rubric evaluations are conducted. Failure to complete the peer reviews by the deadline will result in zero score for the peer evaluation portion of the project.

- **Due:** Wednesday, April 17, 2019 & Friday, May 3, 2019

6.) Presentation (15%)

- Each member of the company is to give a 5- to 10- minute presentation on the design loads, a brief description of design process of different elements in their layout, the superior design, and your NABC value proposition for the company superior design. The presentation must briefly describe the layout, the design of the items set forth in the problem statement, underlying problem (i.e., the need), describe the functionality of the alternative solution (approach), and finally indicate which evaluation metrics led to the choice of your superior design and why those metrics are reasonable (benefits per costs). During the presentation, you will be asked technical questions.
- **Due:** Monday, May 6, 2019. Submit your presentation by 12 p.m.

Appendix 2

Examples of rules set by students:

- All team members will attend planned meeting on time.
- If you cannot attend a meeting, you must notify the group at least 24 hours in advance.
- All applicable books and notes must be brought to group meetings.
- All team members will divide work evenly and produce their best work pn their assigned parts.
- Keep constant, good communication at all times.
- Give honest effort in proceeding with the project.
- Do not be afraid to ask for help from the other team member or the professor.
- Assist other team members whenever necessary.
- Always act ethically.
- Be on time to meetings.
- If any disagreements should arise, ask a third part to help find a solution.
- Wok assigned to each member should be finished by the next meeting, or the assigned date which the group agrees upon.
- Any individual work must be double checked by a fellow group member.

Appendix 3

Examples of questions asked by students:

- Is there a minimum number of rooms required for this residential building?
- Is there a minimum number of certain types of rooms such as bedrooms or bathrooms?
- Are we allowed to design a flat roof?
- Is there a minimum or maximum height requirement per floor?
- Are there any special conditions we need to account for because of the increased likelihood of hurricanes?
- Must the group agree on a general square footage for the building?
- Is there a budget?
- Are any specific ceiling materials required to be used (i.e. plaster ceiling)?
- If design software is used, are hand calculations required for the design handbook as well?
- Wood you truss our design?

Appendix 4
An example of the team charter:

Timber Design Project - Team Charter

Team Name: Shiver Me Timber Design

Team Members: [redacted]

Team Rules:

1. Be on time to meetings
2. Meet all deadlines
3. Be prepared
4. Focus on tasks during meetings
5. Always do your best work

Team Questions:

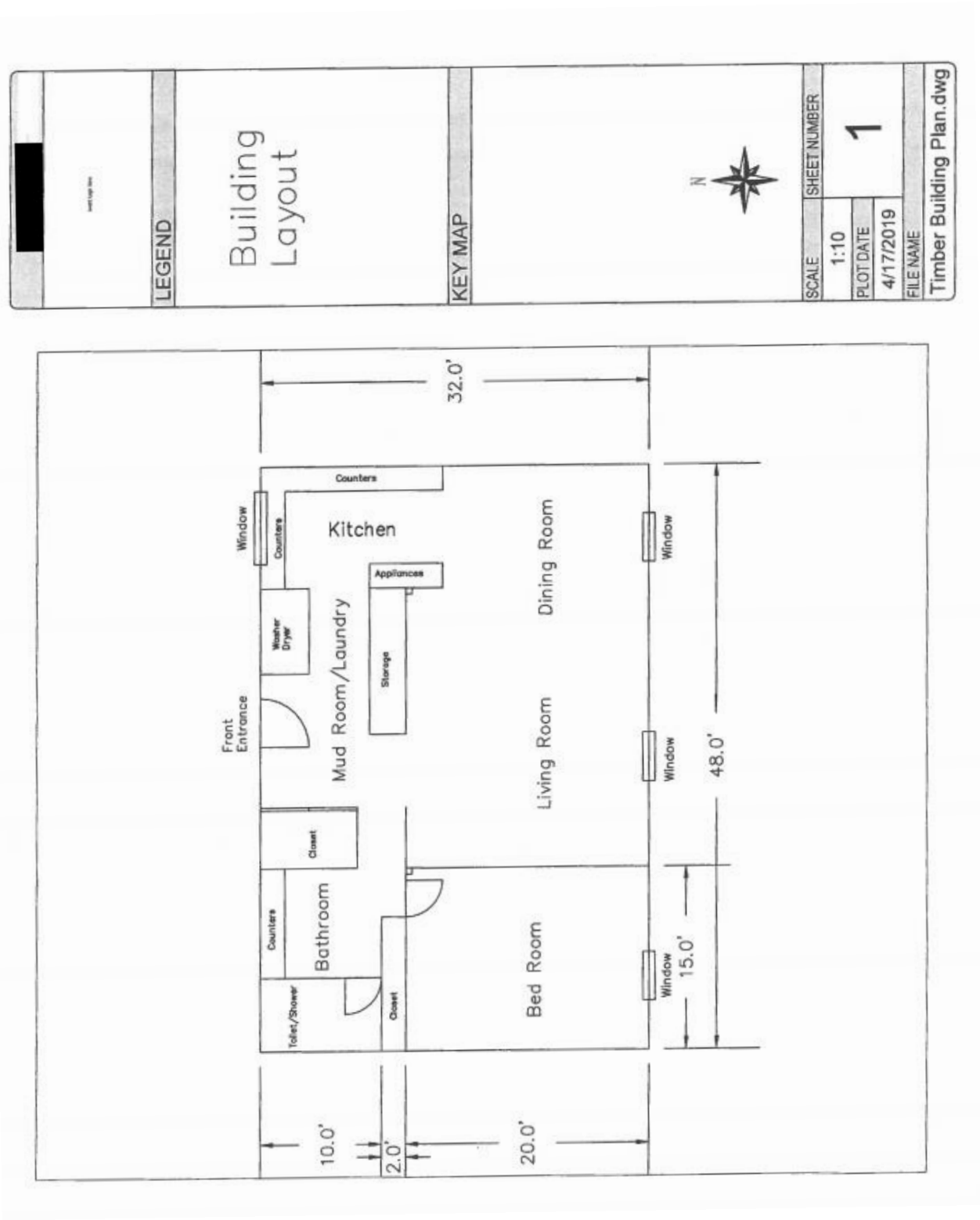
1. Are there any financial constraints on this project?
2. Are we required to design any beams with notches, or is that optional?
3. Where do we get dead load values for a residential home?
4. What is the most reliable source for timber costs?
5. Is there a minimum square footage requirement for each room in the house?
6. Are any specific ceiling materials required to be used (i.e. plaster ceiling)?
7. Should there be a higher minimum wind design for the building since Florida is prone to high winds during hurricanes?
8. If design software is used, are hand calculations required for the design handbook as well?

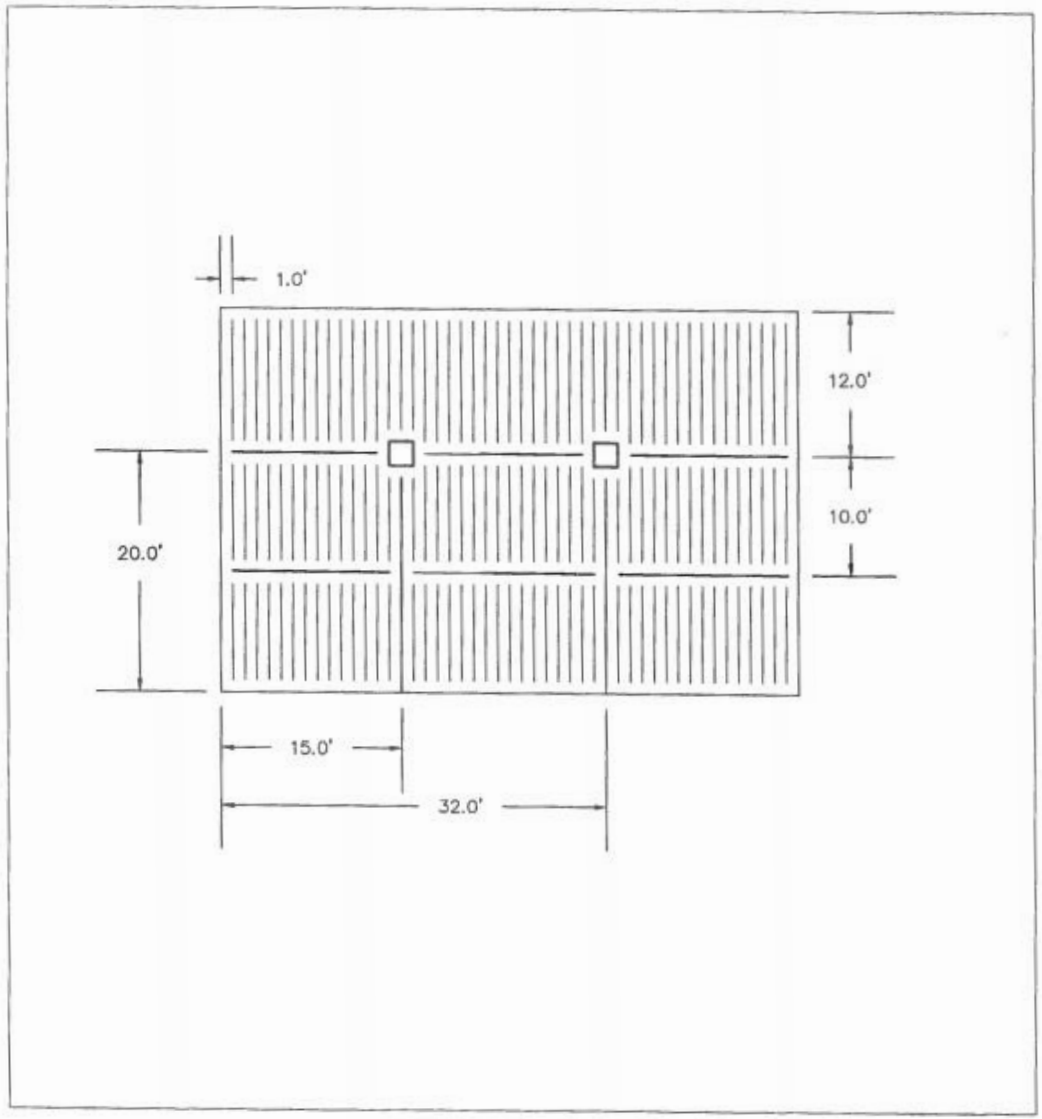
Signatures:

[redacted]

Appendix 5

An example of the building layout:





[redacted]

Framing Plan

LEGEND

Sub Purlin

Purlin

Girder

Column

KEY MAP

N

SCALE	SHEET NUMBER
1:20	2
PLOT DATE	
4/17/2019	

FILE NAME

Timber Building Plan.dwg

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####

####

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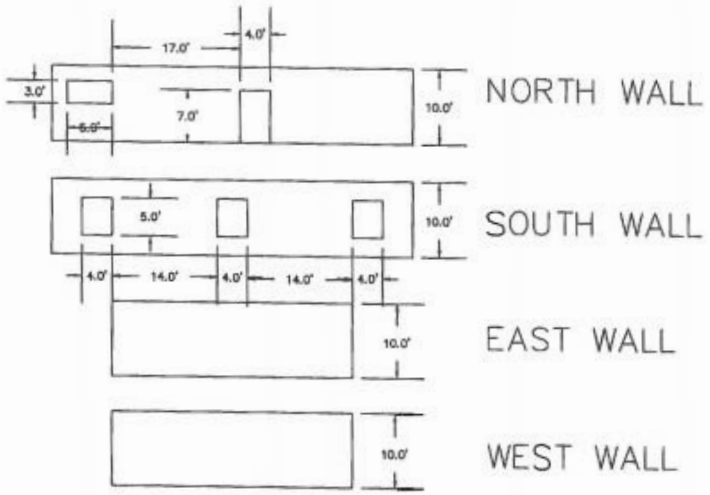

[redacted]

Wall Plan

LEGEND

KEY MAP

N

SCALE	SHEET NUMBER
1:20	3
PLOT DATE	
4/17/2019	
FILE NAME	
Timber Building Plan.dwg	

Appendix 6

Collaborative Work Skills: Teamwork Evaluation

Team Name: _____

Evaluation of: _____ Evaluated by: _____

Directions: **Complete a teamwork evaluation for each member of your team. Circle the description in each category that you feel best describes the behavior or performance of the person you are evaluating. These confidential reviews are to be used by your instructor as an aid in determining your individual and group teamwork scores. Do <u>not</u> discuss how you have scored each other. Confidentiality is needed to ensure scores reflect performance and not personal relationships among team members.**

CATEGORY	4	3	2	1
Working with Others	Almost always listens to, shares with, and supports the efforts of others. Tries to keep people working well together.	Usually listens to, shares, with, and supports the efforts of others. Does not cause "waves" in the group.	Often listens to, shares with, and supports the efforts of others, but sometimes is not a good team member.	Rarely listens to, shares with, and supports the efforts of others. Often is not a good team player.
Focus on the task	Consistently stays focused on the task and what needs to be done. Very self-directed.	Focuses on the task and what needs to be done most of the time. Other group members can count on this person.	Focuses on the task and what needs to be done some of the time. Other group members must sometimes nag, prod, and remind to keep this person on-task.	Rarely focuses on the task and what needs to be done. Let others do the work.
Attitude	Never is publicly critical of the project or the work of others. Always has a positive attitude about the task(s).	Rarely is publicly critical of the project or the work of others. Often has a positive attitude about the task(s).	Occasionally is publicly critical of the project or the work of other members of the group. Usually has a positive attitude about the task(s).	Often is publicly critical of the project or the work of other members of the group. Often has a negative attitude about the task(s).
Time-management	Routinely uses time well throughout the project to ensure things get done on time. Group does not have to adjust deadlines or work responsibilities because of this person's procrastination.	Usually uses time well throughout the project, but may have procrastinated on one thing. Group does not have to adjust deadlines or work responsibilities because of this person's procrastination.	Tends to procrastinate, but always gets things done by the deadlines. Group does not have to adjust deadlines or work responsibilities because of this person's procrastination.	Rarely gets things done by the deadlines AND group has to adjust deadlines or work responsibilities because of this person's inadequate time management.
Quality of Work	Provides work of the highest quality.	Provides high quality work.	Provides work that occasionally needs to be checked/redone by other group members to ensure quality.	Provides work that usually needs to be checked/redone by others to ensure quality.
Contributions	Routinely provides useful ideas when participating in the group and in classroom discussion. A definite leader who contributes a lot of effort.	Usually provides useful ideas when participating in the group and in classroom discussion. A strong group member who tries hard!	Sometimes provides useful ideas when participating in the group and in classroom discussion. A satisfactory group member who does what is required.	Rarely provides useful ideas when participating in the group and in classroom discussion. May refuse to participate.
Problem-solving	Actively looks for and suggests solutions to problems.	Refines solutions suggested by others.	Does not suggest or refine solutions, but is willing to try out solutions suggested by others.	Does not try to solve problems or help others solve problems. Let others do the work.