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ANALYSIS OF THE ENGINEERING STUDENTS' SELF-REFLECTIONS THROUGH TEXT MINING OF THEIR LEARNING STATEMENTS

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SHAN PENG

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ANALYSIS OF THE ENGINEERING STUDENTS' SELF-REFLECTIONS THROUGH TEXT MINING OF THEIR LEARNING STATEMENTS

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BY THE COMMITTEE CONSISTING OF

Dr. Janet K. Allen, Chair

Dr. Xun Ge

Dr. Farrokh Mistree, Co-Chair

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ABSTRACT

At the University of Oklahoma (OU), AME4163: Principles of Engineering Design which is based on the "Design, Build, and Test" approach and has an experiential learning structure, is a course for preparing senior undergraduate students with ability to adapt quickly to new circumstances as junior engineers. In order to measure students' learning effectiveness, instructors require the students to write down their learning statements using a triple construct including experience, learning, and value. The learning statements submitted by the students are the linguistic embodiment of their engineering competencies through reflection on doing which is anchored in Kolb's experiential learning cycle. There are two main issues facing instructors in manually assessing students' learning statements: 1) labor-intensiveness due to the huge amount of text, and 2) subjectivity due to the instructors' personal judgments.

In this thesis, the hypothesis is that through the exploration in the text mining program, the things as follows facilitate instructors analyzing students' learning statements.

- Proposing a text mining framework to answer the development question.
- Formalizing the heterogeneous text contents and building the schemed database in the framework
- Adapting the machine learning methods to analyze and predict the data source.
- Visualizing the text mining results for gaining more insights from the textual documents.
- Automating a text mining program to integrate the functionalities of the framework.

The intellectual merit of this thesis is the realization of the text mining program to gain insights from the linguistic learning statements. By incorporating machine learning methods to analyze the heterogeneous text contents, the text mining program can be updated by experiments, evaluation, and users' feedbacks. Through the improvement of the text mining program, more and more visualization results and the corresponding insights can be generated.

Glossary

TERM	DESCRIPTION
POED	Principles of Engineering Design
TAKE AWAY	Students' reflection for the lecture or assignments
LEARNING STATEMENT	Students' reflection for triple structured sentence with experience, learning and value in engineering design courses
TEXT MINING	The methods for transforming the textual contents into statistical data
VISUALIZATION	The methods for transforming the statistical data into visualized graphs
CBDS	Cloud Based Platform for Design Support

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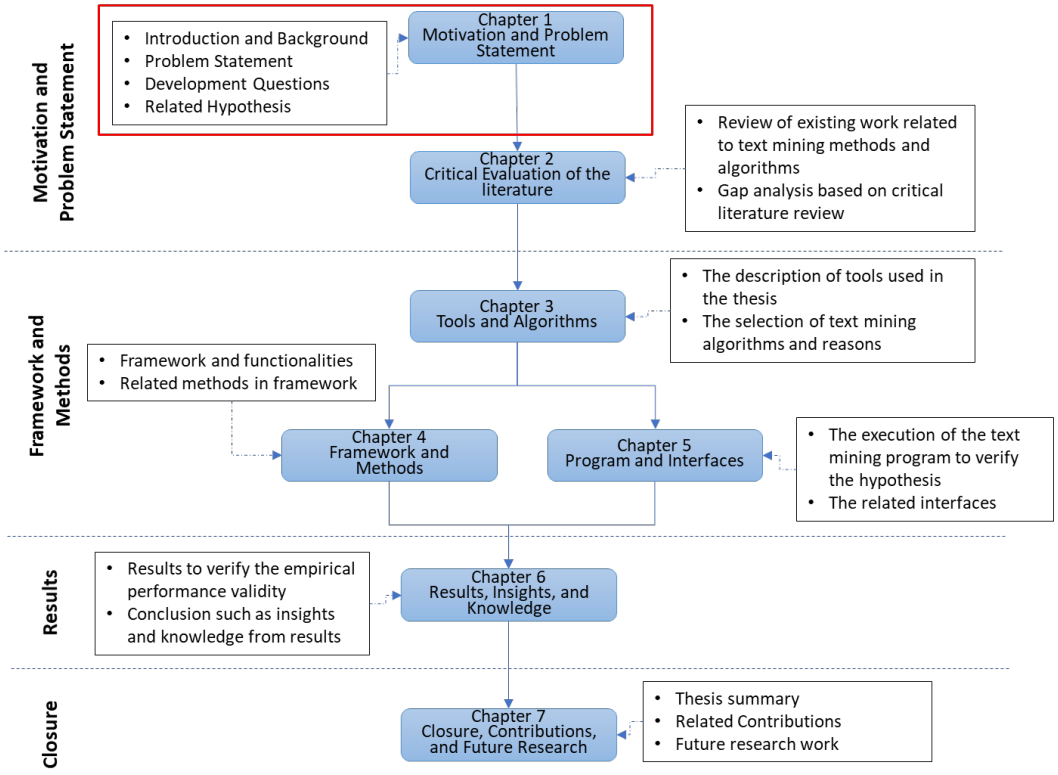
CHAPTER 1 MOTIVATION AND PROBLEM STATEMENT



The thesis work starts from the motivation and questions. In this chapter, the backgrounds of the thesis are proposed to guide the motivation and problem statement of the thesis. The primary development question and sub questions are presented in Section 1.3, and the validation square for the thesis work is proposed in Section 1.4. The organization structure of the thesis with a road map is presented to show the relations between chapters. With the introduction and motivation of the thesis, the question of the thesis will be analyzed and answered in next chapters.

1.1 BACKGROUND AND MOTIVATION

1.1.1 Introduction of OU course: AME 4163

Industry is facing an ever-changing environment. Many companies want their engineer employees to have the ability to adapt to the changing environment [1]. From the education perspective, universities or colleges are also providing programs and courses for engineering students,

especially senior undergraduate students to help them develop their competencies for future careers as junior engineers when they graduate. At the University of Oklahoma(OU), AME4163: Principles of Engineering Design, a course for preparing senior undergraduate students for their future career in engineering through experiential learning [2]. Our goal in AME4163 is to offer students the opportunity to learn by reflecting on doing in an immersive authentic environment. From Appendix.A, the course handbook is used for student to develop the competencies of self-learning and self-assessment. It is hypothesized that by having students reflect on an experience related to a principle of engineering design and articulate a lesson learned that they will develop the ability to continue identify new principles and thence grow professionally [3]. The learning statements are the linguistic embodiment of students' engineering competencies through reflection on doing. As shown in Table 1.1, a learning statement is represented using a text-based [Experience|Learning|Value] construct. By this construct, students record what they learned by reflecting on authentic immersive experiences throughout the semester. The learning statements anchored in the lectures are aimed at getting students to identify a "lesson" that will be of value in completing an assignment. The learning statements anchored in assignments are aimed at helping a Junior Engineer transition from university to a Junior Engineer in industry.

Table 1.1 The Structure of the Learning Statements

Experience x	**Learning y**	**Value / Utility z**
Through **x** (From **x**, By doing **x**, ...)	I learned **y**	
I did not consider **x** initially	I realized **y**	Value / utility **z**
I thought (expected) **x** before / initially	I found out **y**	in future of
	I discovered **y**	learning **y**
	I became conscious of **y**	

There are typically over 150 students attending AME4163 in each fall semester. At the end of the semester, there are collected around 8,000 learning statements from the Junior Engineers about the lectures they attended and the assignments they completed in 2017. The value of these learning statements is anchored in that instructors and teaching assistants can analyze the learning statements and understand what Junior Engineers have individually and collectively learned and whether the outcome is in keeping with what the instructors planned. One option to do this is to have instructors and teaching assistants manually read the learning statements and assess student learning. The key disadvantage of this option is that manually dealing with a huge amount of text-based data (8,000 learning statements per semester) is labor-intensive and time-consuming.

We did this for the first two years and found that maintaining consistency in the assessment was virtually impossible. Hence, our effort to develop a computational framework to aid the instructors in the assessment of the learning statements.

The instructor have identified a number of Principles of Engineering Design (POED); see Figure 1.1. Their principal goal in offering this course is to provide an opportunity for Junior Engineers to internalize the POEDs and to develop competencies that they need to hit the road running as Junior Engineers in their capstone course and in industry after they graduate. The competencies that students are expected to develop in the course include the ability to learn by reflecting on doing, the ability to speculate on future trends and pose questions worthy of investigation, the ability to make engineering design decisions in the face of limited information, the ability to adapt to new circumstances such as a new design team or problem, and the ability to introspect and self-assess to improve as a designer. The instructors act as mentors or coaches to students throughout the course. In the course, students are provided with tools and guidance that enable them to meet the challenge presented in the course. By attending AME4163, students are prepared for their capstone design experience (in another course, AME4553 Design Practicum, where they will need to address engineering challenges from corporate sponsors before they graduate). Accordingly, in AME4163, students are expected to learn how to act like Junior Engineers in professional settings.

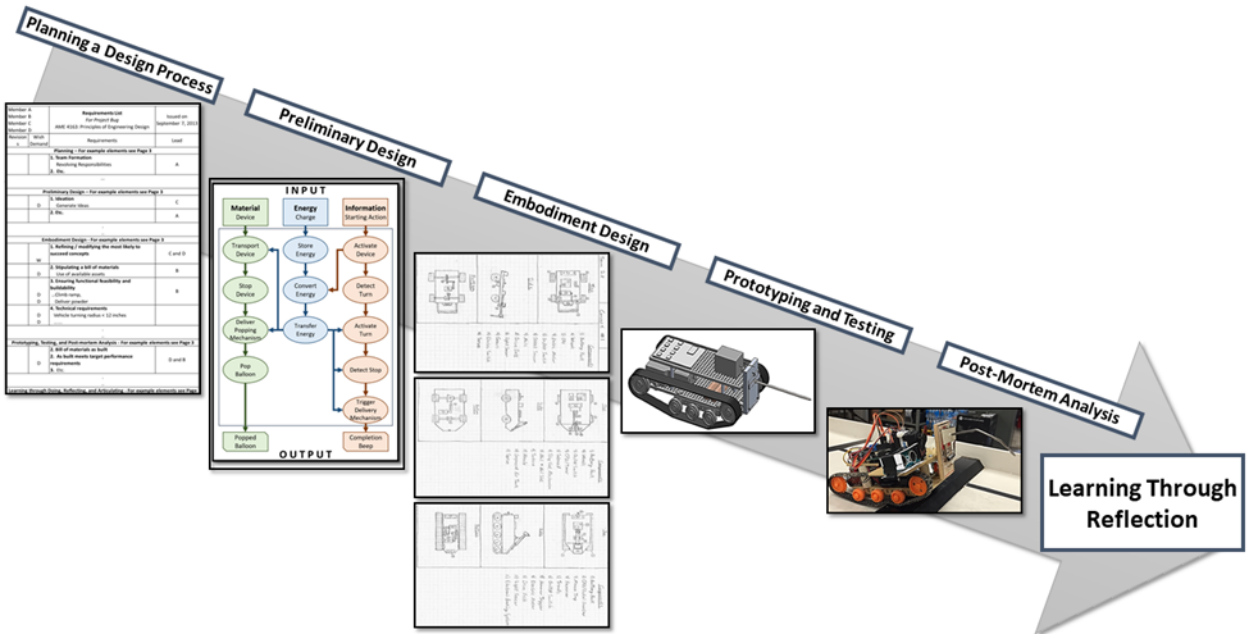


Figure 1.1 Design, Build and Test Project in AME4163

In AME4163, students must complete a semester-long design, build and test project, as shown Figure 1.2, with a team of their colleagues. The is not based solely on how well the student-designed, built electro-mechanical device performs but also on students' learning. By the time they finish the course, they should be able to i) plan a design process by understanding requirements, implement that process, evaluate the outcome, and identify improvements to that process; ii) generate, evaluate, and develop design concepts by applying knowledge of science, engineering techniques, and manufacturing principles; iii) use analysis and simulation tools to understand design performance and then improve the design; iv) generate solid models and engineering drawings of the design using 3D modelling software; v) prototype the design; and vi) learn through reflecting on doing (for example, design, build, test, read, write, etc.) and experiencing (for example, working in a team, getting feedback from mentors). These abilities must be developed by internalizing the related engineering design principles covered in lectures of the course, as shown in Figure 1.2. The principles are associated with five key design stages, namely, 1) planning a design process, 2) preliminary design, 3) embodiment design, 4) prototyping, testing and post-mortem analysis, and 5) learning through doing, reflecting and articulating. Specific principles of each design stage are identified in Table 1.2.

1. **Planning a design process**
   a. Forming a team
   b. Accepting and executing a team contract to stipulate ethical guidelines to decision making and problem resolution
   c. Understanding the problem and framing the problem statement
   d. Proposing a plan of action
2. **Preliminary design**
   a. Ideating and generating concepts
   b. Developing concepts to ensure functional feasibility, ensure realizability (technical feasibility)
   c. Evaluating the concepts (functional feasibility, technical feasibility) and identifying that system concept which is most likely to succeed
3. **Embodiment design**

a. Refining / modifying the most likely to succeed concept through technical analysis, experimentation and thought exercises
b. Stipulating available assets
c. Ensuring functional feasibility, technical feasibility, realizability (buildable within budget and with available skills), and safety

4. Prototyping, testing and post-mortem analysis

a. Creating a bill of materials as built, including an understanding of the limitations and capabilities of the chosen components
b. Ensuring that the design as built meets target performance requirements
c. Performing a critical analysis after device prototyping of causes of success and failure

5. Learning through doing, reflecting and articulating

a. Critically evaluating the processes of designing, building, and testing
b. Articulating, using learning statements, the Principles of Engineering Design that you have internalized
c. Identifying new POED and carrying that knowledge into future projects and experiences

Figure 1.2 POED in AME4163

In order to help students internalize the POED, instructors issue seven assignments for students to finish during the semester. In Table 1.2, the relationship between the target POED to assignments is illustrated. For example, in Assignment 1 (Table 1.2, Column 2), given a story and a team contract which students are required to provide Problem Statement, Plan of Actions, House of Quality, Requirements List, and the Learning Statements. In this assignment, target POED include 1a, 1b, 1c, 1d, and 5b (see Figure 1.2 for details). These are the explicit instructor learning targets for each assignment. It should be noted that students may also reflect on connections between POED and assignments not made explicit by Table 1.2. By leveraging the information in Table 1.2, instructors can judge whether students' learning (reflected by text mining results) in each assignment meets the target POED.

Table 1.2 Structure for Scaffolding the POED and the Assignments

Assignment	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Description / **Target** / **POED**	***Given:*** Story, Team Contract ***Provide:*** Problem Statement, POA, HOQ, Req. List, LS	***Given:*** Prob. Statement, HOQ, Req. List. ***Provide:*** Function Structure, Morph. Chart, 6 Concepts, PMI, Failure, LS	***Given:*** Concepts, PMI, Failure ***Provide:*** Go/No-Go from 6 to 2, Bill of Materials, Select Concept, LS	***Given:*** Selected Concept ***Provide:*** Geometry analysis, CAD model, refined Bill of Materials, Buildability, Report, LS	Post-Mortem Report	Semester Learning Essay	Capstone Plan of Action
1a	×						×
1b	×						×
1c	×						×
1d	×	×	×	×			×
2a		×					
2b		×					
2c		×					
3a			×	×			
3b			×	×			
3c				×			
4a					×		
4b					×		
4c					×		
5a					×	×	
5b	×	×	×	×		×	×
5c					×	×	×

1.1.2 The Learning Statement

In each assignment and at the conclusion of all lectures, each student is tasked with writing learning statements. Learning statements are a way for students to reflect on their experiences and identify key lessons learned. In particular, students are asked to demonstrate that they are both internalizing the target POEDs and formulating an understanding of how they can apply this

knowledge moving forward (both in their education and their later careers). The format for learning statements is shown in Table 1.1. Learning statements take the form of statements which begin with a clause describing the event or activity in which learning took place and end with a description of the learning using action words taken from Bloom's taxonomy. These action words help to assist students in being deliberate in their analysis of learning. When constructing learning statements, students are encouraged to endeavor to demonstrate learning of more than mere technical skills. several example learning statements are shown in Table 1.3, in which students from Fall 2019 describes their experience in team-based assignments (Assignments 1-5).

As shown in Table 1.3, the student who finished Assignment 1 mentioned the importance of understanding the problem and framing the problem statement during the stage of planning a design process. From his/her learning statement we see keywords "understand", "frame", and "problem", that are related to the core of POED 1c in Figure 1.2, therefore we can say that this student has internalized the relevant POED in Assignment 1. The student who finished Assignment 2 mentioned about concept selection in preliminary design. In his/her learning statement, he/she emphasized the role of group-work in selecting the "best" concept, while failed to mention the importance of concept evaluation, which is listed as a target POED (i.e., 2c) for Assignment 2. Additionally, he/she used the term "best" to describe the selected concept, however, in POED 2c, the idea is to select concepts that are most likely to succeed instead of the "best". From these observations, it is concluded that the student failed to internalize the expected POED. Similarly, instructors can extent the rule to evaluate the learning statements regarding to Assignments 3 through 5 and judge whether students have internalized the associated POEDs.

At OU, there are collected around 8,000 learning statements at the end of each fall semester, which brings the problem of information overload in manually evaluating the learning statements. We did this for two years and found that maintaining consistency in the assessment was virtually impossible. Hence, the development of a text similarity based method to automatically assess students' learning statements.

Table 1.3 Learning Statements Examples

Assignment	Stage	Learning Statement Example
1	Planning a design process	Through sitting down and actually looking at the problem, I realized how important understanding the problem and then framing it correctly is, which will help me in the future by allowing me start solving my problem on the right foot and will let me reality check myself easily.
2	Preliminary design	Through the process of finding the best concepts for our design for assignment 2, I learned that when the group works together we are able to find the best design, which will help me better realize the value of groups for future projects as an engineer.
3	Embodiment design	Through the generating concepts sketches, I learned that getting ideas as rough sketches is a great way to determine what is technically and functionally feasible, which will help me to save time and money on projects in college as well has help me save time and money on future professional projects.
4	Prototyping, testing and post-mortem analysis	Through the creation of the Available Assets and the Bill of Materials, I learned how to critically think about the best uses for the team's skills, knowledge, and tools in order to conserve time and stay under budget while making the most competent device, which is valuable to me because a critical analysis of the team's skills and assets is the best way to finish a project effectively.
5	Learning through doing, reflecting and articulating	Throughout the entire project, I learned that establishing strong communication between members not only aids in the technical aspect of project completion, but also helps in forming interpersonal relationships that will also help in creating a better final product, which will help me in my career as a Junior Engineer to make sure to be open, honest, and clear when communicating to my team.

1.1.3 Motivation of the work

The principal motivation for the work arises from the course AME4163 and the related learning statements. Students' learning statements reflect what students have learned from the engineering design course, and what is the value for students to use in their future career. For helping instructors analyze the learning statements to evaluate students' improvement, the text mining work is undertaken the corresponding data which are collected from students' learning and design process grounded in the course pedagogy. Furthermore, the motivation arises from the data analysis need

to get the meaningful visualization results and construct the text mining framework with suitable technologies. At the meantime, the need for students to develop the relevant competences in their future Junior Engineer career drives instructors gaining insights from students' learning statements. In Chapter 1, the background of course AME4163, and the motivation of the work are introduced in the thesis. In Section 1.2, it is presented the problem statements of the thesis and find out the hypothesis to resolve the thesis development question.

1.2 PROBLEM STATEMENT

In the thesis, the problem for instructors in the course AME4163 is how can the text mining framework help their assessment and students' self-assessment for better performance in the engineering design course which student learning through reflection on doing is the core of the course. As it is said in Section 1.1.3, the problem is identified in the need of students to develop the relevant competences to adapt the rapidly changing industry environment. Particularly, the analysis task of the feedback from students in the course is huge for instructors, over 8,000 learning statements per year. If instructors analyze these reflections manually, it would be a time-consuming and human resource using work which needs a lot of time or many assistants to complete the analysis task. Different instructors and assistants have different intuition to gain insights from students' reflection, and it leads to the different conclusions for instructors to dig the problems of the course and improve the course lectures. These drawbacks of manual analysis in students' learning drive me to find the suitable methods to automatically analyze the data.

The automatic analysis of text contents is using different text mining methods to compute the text data with automatic cleaning tools. Through the text mining program to deal with students' reflection, the analysis results can be used to help instructors conclude the students' learning and value for improving the course. The automatic text mining program could be consistent to implement the functions for analyze the data and get individual and objective results for instructors. The consistent process takes effect in the data of different years and sections for getting the insightful results and comparing these results from the unified perspective. Actually, there are lots of text mining methods can be selected to analyze the text contents. What are the suitable methods for analyzing students' learning statements and getting the meaningful results? That is the question which is proposed in Section 1.3 with feasible hypothesis to answer the question.

1.3 THESIS DEVELOPMENT QUESTIONS

1.3.1 Development Questions

The primary development question in this thesis is how a text mining program can be used to allow instructors to gain insights from learning statements of OU course: AME4163. The related hypothesis is that by designing an integrated framework with multiple text mining algorithms and implementing the framework in a program, the mining results could be visualized and provide insights to instructors. For solving the primary question, it is discovered the gaps between the current research work and my expectation goals. There are three divided sub questions based on gap analysis. The gap analysis is proposed in Section 2.2. And the detailed hypothesis are presented in Section 2.3.1. With the related hypothesis, it is constructed a text mining framework in Chapter 4 to realize these functions. In Chapter 6, meaningful mining results are visualized from students' learning statements in past three years. With these results and summarized conclusions, the primary development question can be answered in Chapter 7.

Table 1.4 Development Questions

Thesis Development Questions	**Primary**	**Question:** How can a text mining program be used to allow instructors to gain insights from the original text source?
		Related Hypothesis: By designing an integrated framework with multiple text mining algorithms and implementing the framework in a program, the mining results could be visualized and provide insights to instructors.
	Secondary	**Gap 1:** Formalization of unstructured and heterogeneous textual documents
		Sub question 1: What is the appropriate method for handling large amounts of text data in the program?
		Hypothesis 1: A function for users to configure extraction rules can support users to deal with the large amounts of learning statements data.
		Gap 2: Generation of meaningful results from the text contents
		Sub question 2: What is the way for comprehensive mining of the learning statements to enable one to obtain meaningful results?
		Hypothesis 2:

		Integrating multiple text mining algorithms in a program can facilitate comprehensive mining of the learning statements from different perspectives.
		Gap 3: Intuitive representation of the text mining results
		Sub question 3: How to visualize the text mining results to facilitate instructors gaining new knowledge from the learning statements?
		Hypothesis 3: Using visualization tools such as word cloud, histogram, text network, and radar chart can help instructors gaining new knowledge or insights from the learning statements.

1.3.2 The Relation between Questions and the Work

In Section 1.3.1, the primary development question is presented as the motivation for the thesis to help instructors gain insights from students' reflection. Three sub questions are extended from the primary development question and divided with three parts: data preprocessing, data analysis and results visualization. In the following chapters, the tools for analyzing the textual contents are described to verify the theoretical structural validity in Chapter 3. The stemmer algorithms and stop-words filter tools of Section 3.2 are the data cleaning tools to answer sub question 1 theoretically. The text mining algorithms in Section 3.4 are explained to validate the selection results for text analysis. The visualization tools, such as word cloud and text network are presented to verify the conclusions from the visualization graphs in Section 3.5. The text mining framework and related functions are constructed to verify the empirical structural validity in Chapter 4. The functions of data cleaning, data management, text analysis and visualization results are individually proposed the appropriate methods in the framework to verify the thesis empirically. The text mining program in Chapter 5 is supplied for the methods and functions of the text mining framework to verify the thesis from the empirical perspective. The visualization results generated from the learning statements in three year are presented with different perspectives and reflected insightful comments to improve the engineering design course. The results in Chapter 6 are verified the empirical performance validity. The works in Chapter 3, 4, 5, and 6 are separately related to different sub question and presented to answer these questions from different perspectives.

Table 1.5 The Relation between Questions and the Work

Relevant Sections: Development Questions	Chapter 3				Chapter 4				Chapter 5	Chapter 6		
	3.2	3.3	3.4	3.5	4.2	4.3	4.4	4.5	5.2	6.1	6.2	6.3
How can a text mining program be used to allow instructors to answer research questions in learning statements of OU course: AME4163?	√			√	√			√	√	√	√	√
What is the appropriate method for handling large amounts of text data in the program?	√				√	√			√			
What is the way for comprehensive mining of the learning statements to enable one to obtain meaningful results?			√				√		√			
How to visualize the text mining results to facilitate instructors gaining new knowledge from the learning statements?				√	√			√		√	√	√

1.4 VERIFICATION AND VALIDATION OF THESIS CHAPTERS

It is a complicated processing to define the validation for verifying the methods which are used to answer development questions. Two ways are used to construct the validation of the thesis. The first way is verification which is used to verify the correctness of hypothesized methods, and the second one is validation which is used to validate the usefulness of generated results. Through the verification of proposed methods, the results should be generated consistently as methods expected. Through the validation of generated results, the comments and suggestion which are extended by the results should be used to validate the value of what is presented to continue with the development questions. In Figure 1.3, it is illustrated the relations between verification and validation.

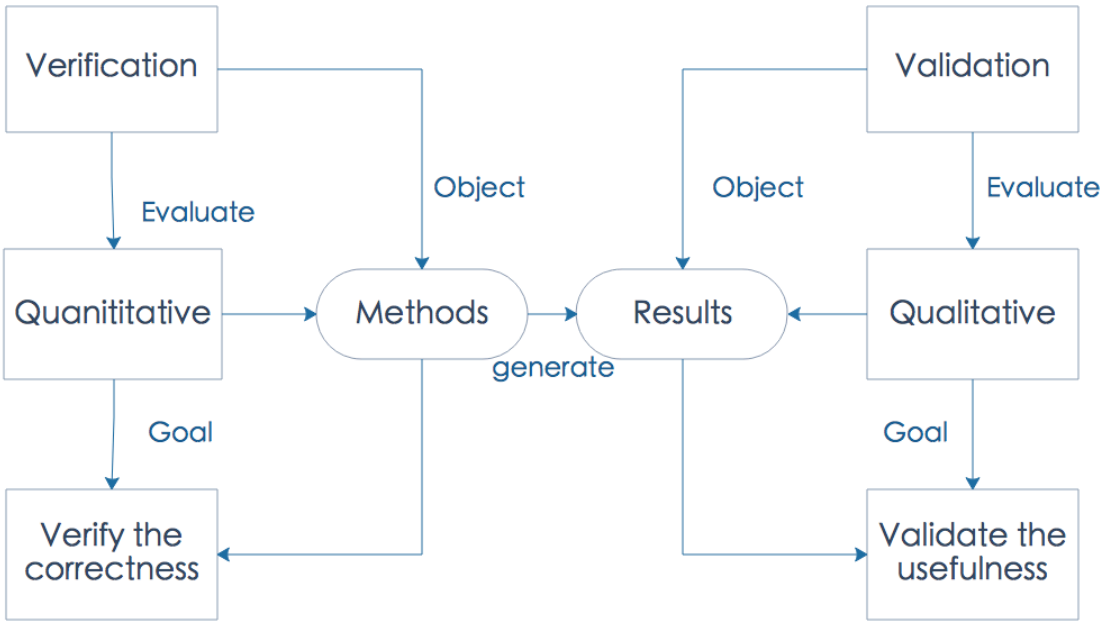


Figure 1.3 The Relations between Verification and Validation

The validation square is used to connect each chapters with validating the work. The logic flow of chapters in the thesis is also presented in the validation square. The validation and verification square framework is introduced to help verify the answers of proposed research questions and gaps. Figure 1.4 is the detailed validation square of the thesis chapters.

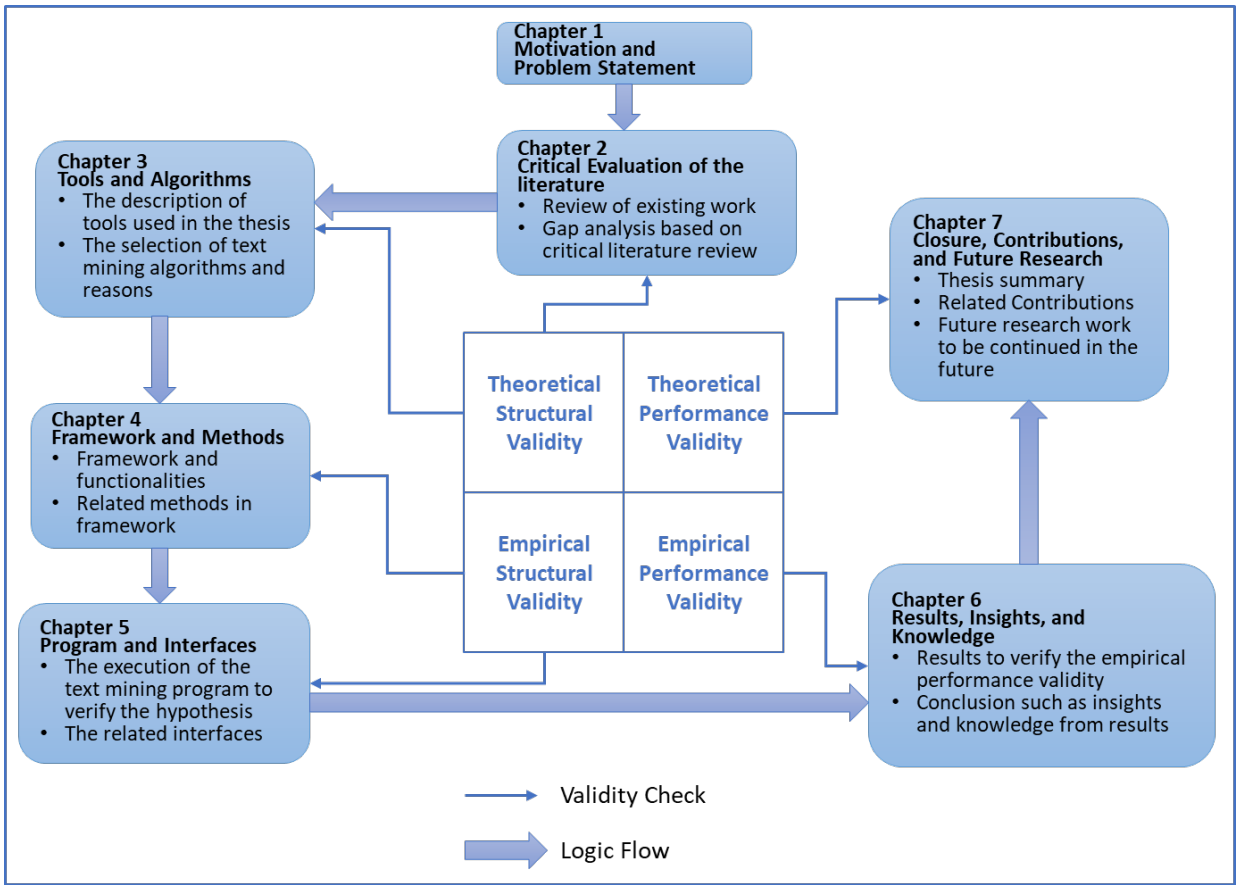


Figure 1.4 Validation Square of the Thesis

From the validation square, the detailed framework is used to validate the usefulness of the methods and results which is associate with whether the design of methods provides correctly namely structural validity, or whether the methods provides correct solutions namely performance validity. The validation square consists of four parts: theoretical structural validity, empirical structural validity, empirical performance validity and theoretical structural validity. Four validity parts verify the methods and applications of this thesis, shown as below.

1. Theoretical Structural Validity (TSV) – *The verification question is that is the design method internally consistent.*

   - In Section 1.1 and 1.2, The background information and problem statements are presented for proposing the development questions of the thesis.
   - The development questions and related hypothesis are logically formulated to cover the problem statements in Section 1.3.
   - In Chapter 2, the relevant literature is critically reviewed in engineering design education

domain and text mining domain for identifying the research gaps

- The relevant application domain and limitations for the developed concurrent tools and text mining algorithms are discussed in Section 3.2 and 3.3.

2. Empirical Structural Validity (ESV) – *The verification question is that are the example problems used in modeling the method appropriate choices.*

   - The text mining framework and related functionalities are presented in Section 4.2 for verifying the hypothesis.
   - In Section 4.3, the challenging aspects of the data cleaning methods are discussed to argue that the aspects are appropriate to test Hypothesis 1 of the thesis which is proposed in Section 1.3.1. Data cleaning methods are used to transform the unstructured text data into structured and remove the insignificant parts of the text contents.
   - In Section 4.4, the challenging aspects of the text mining methods are discussed to argue that the aspects are appropriate to test Hypothesis 2 of the thesis which is proposed in Section 1.3.1. Text mining methods are used to compute and analyze the data for understanding the text contents from different perspectives.
   - In Section 4.5, the challenging aspects of the visualization methods are discussed to argue that the aspects are appropriate to test Hypothesis 3 of the thesis which is proposed in Section 1.3.1. Visualization methods are verified that visualizing the text mining results is more easily to gain insights.
   - In Chapter 5, the execution of the text mining program and relevant interfaces are presented to verify the methods which are mentioned in Chapter 4.

3. Empirical Performance Validity (EPV) – *The verification question is that does the application of the method to the sample problems produce practical results.*

   - In Section 6.1, text frequency results are visualized appropriately for testing the hypothesis of the thesis with the graphs of histogram and word cloud.
   - In Section 6.2 and 6.3, different visualization results are used to validate the hypothesis based on the graphs of radar chart and text network.
   - Many conclusions such as insights and knowledge are concluded from the visualization

results in Chapter 6.

4. Theoretical Performance Validity (TPV) – *The verification question is that does the application of the method to other problems produce practical results.*

   - In Section 7.1, the thesis work and related contributions are summarized for verifying the hypothesis of the thesis.
   - In Section 7.4, the future research work is identified that will be based on this thesis and expanded beyond the results presented in Chapter 6.

Table 1.6 Connections between Development Questions, Chapters and Validation Square

Development Questions / Chapters	1	2	3	4	5	6	7
How can a text mining program be used to allow instructors to answer research questions in learning statements of OU course: AME4163?	TSV	TSV	TSV	ESV	ESV	EPV	TPV
What is the appropriate method for handling large amounts of text data in the program?	TSV		TSV	ESV		EPV	
What is the way for comprehensive mining of the learning statements to enable one to obtain meaningful results?	TSV	TSV	TSV	ESV	ESV	EPV	TPV
How to visualize the text mining results to facilitate instructors gaining new knowledge from the learning statements?	TSV		TSV	ESV	ESV, EPV	EPV	TPV

1.5 THE ORGANIZATION STRUCTURE OF THE THESIS

1.5.1 Overview of the Structure of the Thesis

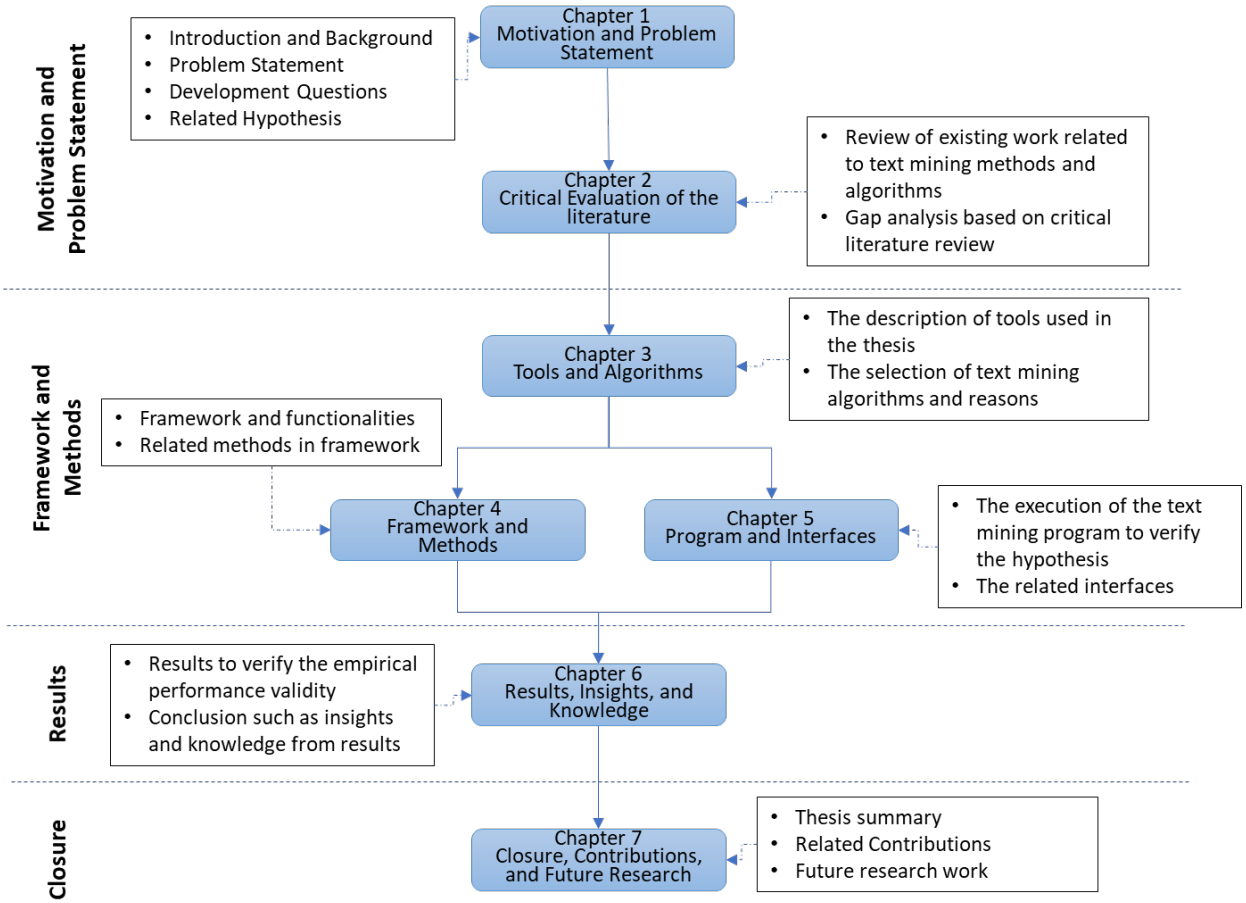


Figure 1.5 Structure of the Thesis

The thesis includes four parts: 1) motivation and problem statement, 2) framework and methods, 3) results and 4) closure. Chapter 1 is the introduction and background for the thesis to present the problem statement of the thesis, and Chapter 2 is the critical review of existing work for gap analysis in the thesis. For the part of framework and methods, the tools in Chapter 3, the framework and related functions in Chapter 4 and the text mining program in Chapter 5 are proposed to verify the practicability of methods and results generated from these methods. The visualization results from Chapter 6 are reflected the insightful conclusions for instructors to understand students' learning and improve the course for future students. Chapter 7 is presenting to summarize the thesis

work and contributions, and future research work is expected to answer other questions and gain more insights in the future.

1.5.2 A Road Map for the Thesis's Work

In Chapter 1, motivation for pursuing the thesis's work is established to propose the problem statement in the thesis. The problem statement is accomplished by proposing the primary development question and related sub questions. In Chapter 2, critical reviews of the relevant literature is presented to extend the material of background in Chapter 1. The reviews of research in engineering education domain and text mining domain present the existing work and identify the gaps between others' research work and this thesis's work. The hypothesis based on the gaps helps to answer the primary development question theoretically.

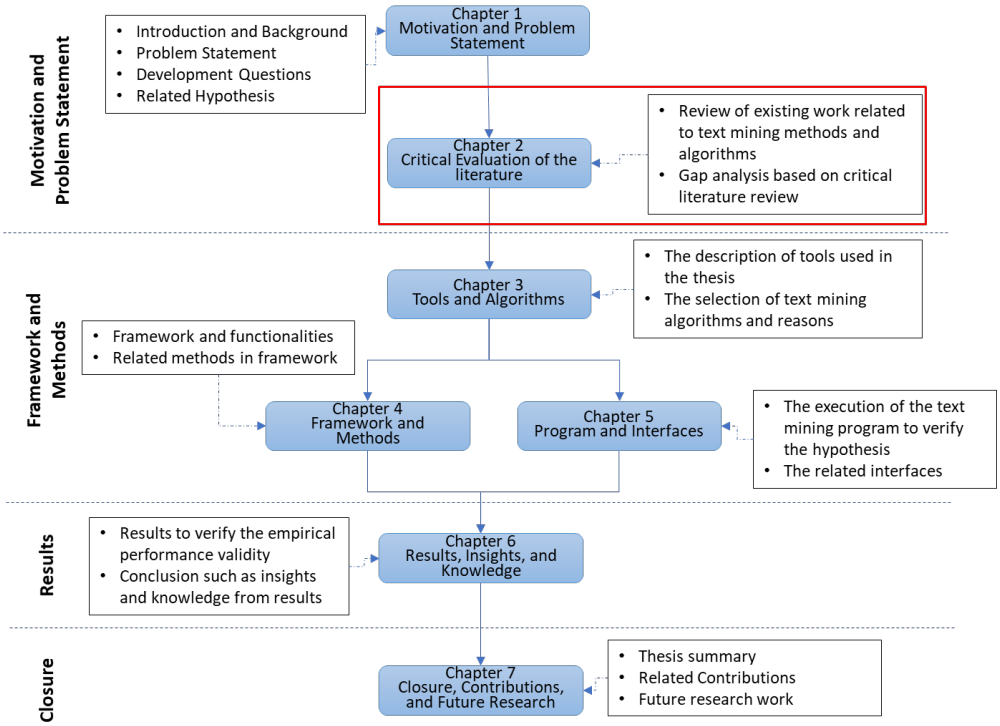
In Chapter 3, the tools for data cleaning, data management, text analysis and text visualization are exploring to validate the practical methods for analyzing student's triple structured reflection. The tools are presented from different perspectives to accomplish one part of gaps that feasible tools are suitable to use in the text mining framework. The text mining framework and related functions are elaborated in Chapter 4. The indicated methods of these corresponding functions are fulfilled for the text mining framework. The text mining framework validates the realization for analyzing learning statements from the empirical perspective. And the text mining framework help to develop the text mining program in Chapter 5. The original textual data is translated with the workflow of the text mining program for getting the visualization graph. In Chapter 5, the verification of the text mining program in Section 5.3 validates the consistent reflection between the original data and the final graphs. From the theoretical methods presented in Chapter 3,4 and 5, the expected results generated by the text mining program are used to present in Chapter 6 and reflect the conclusions for instructors to gain insights.

In Chapter 6, different visualization results are presented to compare with different years and different sections. The differences and common features of the textual data could be easily detected in multiple visualized graphs. For example, the comparison of word cloud in different sections reflects different attention students paid on the lectures. Other visualization results reflect more insightful conclusions for instructors to find out. Through the comparisons and conclusions from the visualization results, the primary development question of the thesis are well answered with

the contributions of the research works. By answering the questions of the thesis, the effectiveness of the text mining framework is identified and verified.

The summary of the thesis works is presented in Section 7.1, and the relevant contributions are proposed based on the thesis works, analysis results and comments. The analysis processing of the thesis is concluded in the section of 'I' statement. With completed works in the current thesis status, future works are outlined in Section 7.4 to build upon the completed works so that future research questions in future research time will be identified for discovering more gaps and creating more knowledge.

CHAPTER 2 CRITICAL EVALUATION OF THE LITERATURE



In Chapter 1, background information is presenting the course AME4163 Principles of Engineering Design and related students' reflection, including take away and learning statement. The motivation of the thesis work is proposed after introducing the data source in Section 1.1. The primary development question in the thesis is identified with three sub questions. Through the development questions, validation square is constructed with the remaining chapters of the thesis. In this chapter, literature related to the engineering design education and text mining domain is evaluated to find out gaps between the existing research works and the thesis work. Through three research gaps, the associated hypothesis are proposed in Section 2.3. With these critical reviews for the thesis work in Chapter 2, the analysis of gaps and hypothesis helps to propose a framework with theoretical structural validity, which maps to Quadrant 1 of the Validation Square in Section 1.4.

2.1 CRITICAL REVIEW OF THE EXISTING WORK

2.1.1 Review of Research in Engineering Education Domain

David Kolb [4] established an experiential learning framework in 1970s, which is the one of most important theoretical constructs in engineering education domain. When the framework is proposed, lots of researchers use this experiential learning framework in their engineering design courses and find out it is suitable for students learning by taking an authentic immersive experience to develop required competences. In the experiential learning framework, Kolb [4] proposed a experiential learning cycle which includes four steps, 1) students start to learn in an authentic immersive experience environment; 2) students observe and reflect their experience after learning; 3) students abstract conceptualization from their reflection; 4) students integrate all the experiences, reflection and conceptualization to summarize and move forward. If students' self-assessment is not matching their expectation, they can go back to the first step and plan to learn more. In the engineering design course, students engage with realistic design challenges, find out design solutions, and verify the solutions through learning with the experiential learning cycle.

Based on Kolb's experiential learning cycle, Jonassen and Hung [5] proposed an improved instructional model, Problem-Based Learning (PBL) model. In the PBL model, an instructional design innovation is presented in many technical disciplines, especially the medical education domain. In medical education courses, students suffered from many issues and one of them is that graduated physicians have learned enough theoretical knowledge but struggle to use these knowledges into practice. The PBL model constructs some practical problem-solving lectures for students to transform the theoretical knowledge into practicum learning. Jonassen and Hung [5] presented the PBL model is suitable for students to learning in an authentic immersive experience to solve realistic problems in their courses. At the meantime, the PBL model is used to collaborate and generate the experiential process by self-assessment.

Balmer [6] developed a new experiential learning framework for the course AME4163, which is a project-based design course for senior undergraduate students to develop the competencies, such as self-assessment and self-learning, as junior engineers. The course is constructed with a practical project through a new experiential learning cycle based on Kolb's cycle. The new experiential learning cycle is described in Section 1.1.1, and the foundation of learning statements in Section

1.1.2. The analysis of learning statements is the requirement for the thesis and incorporated in Chapter 6. The work of Balmer [6] contributes to develop an authentic immersive experience for students which are composed with a design project and the related technical problems.

The work of Dym et al. [7] asserts that students require to confront the unknow problem, find out the complex requirements and propose the flexible plans of actions. Meanwhile, Dym et al. [7] emphasized the role of PBL model in encouraging students to develop the related engineering design competencies and general competencies which help students keeping learning latest design competencies in their future career. The PBL model and the work of Dym et al. [7] help researchers finding out ways to improve students' learning in the engineering design education domain.

With an ever-changing industry environment, senior undergraduate students who are becoming junior engineers soon are required to develop the competencies, such as self-assessment and self-learning to help students suit the technical challenges in the engineering design courses. In the course AME4163, instructors use experiential learning to help students reflect their learning and general their own principles of engineering design to achieve the learning objectives. Students' reflection includes take away and learning statement and course instructors could evaluate students' learning result by analyzing their reflection. In the thesis, the focus is using text mining methods to analyze students' learning statements for the goal which is that instructors can gain insights and improving the course for future students. In the course AME4163, the technical and theoretical knowledge is helping students to complete complex engineering design projects for developing the related practical design skills. Smith et al. [8] proposes in his research that students perform better in project-based design courses with developing the competencies of self-assessment and self-learning. Furthermore, Smith et al. [8] works on the relation between students' performance and their reflection during the course. The authors conclude that the students' reflection can be used to help instructors evaluate their performance and discover the weakness parts of the course. Analyzing students' reflection is a significant work in the thesis to discover the potential patterns for instructors to gain insights and create new knowledge.

In this section, the literature is reviewed with relating to the experiential learning model using in the engineering design domain. And in the course AME4163, the adjusted Kolb's cycle help students reflect the observation and abstract conceptualization from the course lectures. By analyzing students' reflection, the related students' performance could be evaluated and improved.

More analysis results of students' reflection state in Chapter 6. There are more insightful finding and conclusions to help instructors improve the course for future students in future years.

2.1.2 Review of Research in Text Mining

Table 2.1 Critical Review of Research in Text Mining

	Data Cleaning	Data Management	Text Analysis	Visualization
Reidsema and Mort [9]	√		√	
Mooney and coauthors [10]	√			
Xu and coauthors [11]	√			
Agichtein and coauthors [12]	√		√	
Castellanos and coauthors [13]	√			
Haddi and coauthors [14]	√			
Tang and coauthors [15]	√			
Nimmagadda and coauthors [16]		√		
Turk [17]		√		
Yafooz and coauthors [18]		√	√	
Neto and coauthors [19]			√	
Trstenjak and coauthors [20]			√	
Mahgoub and coauthors [21]	√		√	
Larsen and coauthors [22]			√	
Gomaa and Fahmy [23]			√	
Cosine Similarity [24]			√	
Euclidean distance [25]			√	
Matching Coefficient [26]			√	
Latent Semantic Analysis (LSA) [27]			√	
Explicit Semantic Analysis [28]			√	
Normalized Google Distance [29]			√	
Hyperspace Analogue to Language [30]			√	
WordNet [31]			√	
Nenadić and coauthors [32]			√	
Mihalcea and coauthors [33]			√	
Islam and coauthors [34]			√	

Aliguliyev [35]			√	
Huang [36]			√	
Van Driel and coauthors [37]			√	
Inverse Document Frequency (TF-IDF) [38]			√	
Kucher and coauthors [39]				√
Chi and coauthors [40]				√
Kulahcioglu and coauthors [41]				√
Malheiros and coauthors [42]			√	√
This thesis	√	√	√	√

In different domain, text mining methods are used to analyze their unique formats of textual documents by customizing the appropriate functions. In this thesis, a text mining framework is proposed to deal with students' reflection which are discrete pre-defined triple structure sentences. As mentioned in Section 1.1.2, instructors expect to manage students' learning by evaluate their reflection. Through reflecting learning on doing, students can develop the competencies of self-assessment and self-learning. And using text mining methods, students' reflection can help instructors quickly reveal the outstanding or weakness in students' learning and improve the course for future students. In addition, the analysis of learning statements discovers the internal patterns that can be useful to screen out appropriate patters to teach students writing and self-assessing, such as focusing on the quantified and qualified aspects of learning statements. Students know from these patterns to adjust the words, key phrase, and sentences structure for better reflecting their learning. Reidsema and Mort [9] also work on analyzing students' structured reflection and propose that higher level of students' learning insights is connected to certain patterns from their reflection, such as structure and key words.

For analyzing students' reflection learning statement, in this thesis, appropriate text mining methods are used to compute and visualize these reflections. Before using text mining methods, there is a preprocessing step required to deal with the learning statements, which is called data cleaning. The goal in data cleaning is to preprocess the textual content of a document so that interesting contents are extracted or transformed to a required format. For example, Mooney and coauthors [10] discuss information extraction methods and implement systems that extract concrete text corpora of biomedical abstracts, job announcements, and product descriptions from

a set of unstructured documents. Xu and coauthors [11] propose a machine-learning-based method for identifying whether a sentence in an electronic document is bad and remove bad sentences from the document. Agichtein and coauthors [12] propose an automatic segmentation method for segmenting unstructured text strings into structured records so as to facilitate importing the information contained in legacy sources and text collections into a data warehouse for subsequent querying, analysis, mining and integration. Castellanos and coauthors [13] present a method for removing or replacing dirty text from a document by leveraging existing domain knowledge. Haddi and coauthors [14] propose a method for extracting online opinions from social media big data using support vector machines. Tang and coauthors [15] propose a method for cleaning noisy data from emails which includes four passes: non-text filtering, paragraph normalization, sentence normalization, and word normalization.

After dealing with the textual data, the cleaned data needs to be stored together for accumulating in a reusable and retrievable way. The next step, data management is used to capture and manage key attributes of documents or to structuralize the unstructured text in a database. Data management is important because it provides a structured and organized data source for statistical analysis of the textual documents. Nimmagadda and coauthors [16] use ontologies for managing the contextual knowledge of alphanumeric textual data in a digital document ecosystem. The ontology can deliver text-mining, the semantic and schematic information of textual data, and can expedite the textual-data integration process in the multidimensional warehouse modelling procedure. Turk [17] proposes a construction design document management schema which suggests that a document should be used as a larger data chunk instead of records, attributes and primitive objects, and present the document management prototype. Yafooz and coauthors [18] propose a method to automatically organize unstructured information in relational database management systems through linkages among textual data based on semantics.

Text analysis is the core of the text mining framework. Text analysis is used to discover the hidden patterns in textual documents by quantification of the text using different methods. For example, Neto and coauthors [19] propose a method for document clustering and text summarization. They use the so-called “Autoclass” for clustering the documents and use the TF-ISF (term frequency – inverse sentence frequency) measure which is an adaptation of the conventional TF-IDF (term frequency – inverse document frequency) measure to do text summarization. Trstenjak and coauthors [20] propose a text classification method by integrating the k-nearest neighbors (KNN)

algorithm and the TF-IDF method. The method enables classification according to various parameters and measurements. Mahgoub and coauthors [21] propose a method for automatically extracting association rules from text by integrating XML technology with information retrieval scheme (TF-IDF). Larsen and coauthors [22] describe an unsupervised, near-linear time text clustering system that offers a number of algorithm choices for feature extraction and clustering.

In the text analysis function, text similarity algorithm is one text mining methods, which measures are key to many natural language processing applications such as information retrieval, topic detection, text summarization, essay grading, paraphrase recognition, plagiarism detection, etc. In the text mining framework, text similarity algorithm is used to measure the degree to which learning statements successfully match the expectations of the instructors in the assignments. Gomaa and Fahmy [23] conduct a survey of text similarity approaches. They classify existing text similarity approaches into three categories, namely, string-based, corpus-based, and knowledge-based similarities. String similarity measures operate on string sequences and character composition. Several well-known vector spaces measures such as Cosine Similarity [24], Euclidean distance [25], and Matching Coefficient [26] are classified as string-based approaches. Corpus-based similarity is a semantic similarity measure that determines the similarity between words according to information gained from large corpora. Latent Semantic Analysis (LSA) [27] is a typical corpus-based similarity approach. LSA assumes that words that are close in meaning will occur in similar pieces of text, uses matrix to record word counts per document, and applies a mathematical technique called singular value decomposition to reduce the number of rows while preserving the similarity structure among columns. Other corpus-based similarity approaches include Explicit Semantic Analysis [28], Normalized Google Distance [29], Hyperspace Analogue to Language [30], etc. Knowledge-based similarity is another semantic similarity that measures the similarity between words using information derived from semantic networks. WordNet [31] is a popular semantic network for measuring knowledge-based similarity.

The applications of text similarity methods range from individual words to large documents. For example, Nenadić and coauthors [32] use a combined (lexical and functional) similarity measures to automatically recognize and cluster terms in the domain of molecular biology. Mihalcea and coauthors [33] propose a corpus-based and knowledge-based hybrid text similarity method to measure the semantic similarity of short texts such as abstracts of scientific documents, imagine captions, product descriptions etc. Islam and coauthors [34] propose a corpus-based and string-

based hybrid method for computing the similarity between two sentences or two paragraphs. Aliguliyev [35] propose a sentence similarity and sentence extractive technique for automatic document summarization. Huang [36] compares the performance of several distance/similarity measures such as squared Euclidean distance, cosine similarity, and relative entropy etc. in the clustering of a large number of unordered text documents. Van Driel and coauthors [37] propose a text similarity analysis method to classify human phenotypes contained in the Online Mendelian Inheritance in Man database.

In AME4163, learning statements are structured sentences (see the structure in Table 1.1), instructors' expectations are also sentencing which are listed as POED items; see Figure 1.2. When reading/evaluating students' learning statements, instructors typically pay attention to the keywords used by the students and whether these keywords are similar to the target POEDs. Keywords and their occurrence frequencies are critical for indicating whether students' learning results match what they are expected to learn. In the light of this, a Cosine Similarity method is proposed based on Term Frequency – Inverse Document Frequency (TF-IDF) [38] to compute the similarity between learning statements and POEDs. Details of the method is discussed in Section 3.4.2.

The last step, results visualization is used to display the mining results in a meaningful way so that researchers can easily understand the patterns from the textual documents. Kucher and coauthors [39] conduct a survey of text visualization techniques and describe the visualization tasks such as region of interest, clustering/classification/categorization, comparison, overview, monitoring, navigation, and uncertainty tract, etc. Chi and coauthors [40] propose a time-varying word cloud visualization method that uses rigid body dynamics to arrange multi-temporal word-tags in a specific shape sequence under various constraints. This method can attract people's attention by the spatial shapes and temporal motions of word clouds. Kulahcioglu and coauthors [41] present a type of word cloud that enables the selection of affect-aware font and color palette to facilitate more informed choices and generate a stronger emotional impact on users. Malheiros and coauthors [42] present a visual text mining tool to aid systematic reviews of research topics in the software research community.

Through these discussion, it is acknowledged that the functionalities of a text mining framework such as data cleaning, data management, text analysis, and visualization have been well studied in

the existing literature. Researchers propose methods or develop computational frameworks to address problems in specific domains (e.g., emails, social media, construction engineering documents, etc.) with emphasis of different text mining functionalities. However, to the best of our knowledge, there is a lack of a computational framework or system for mining the textual data generated in engineering courses that embodies students' learning by reflecting on doing. It is recognized that Voyant Tools1 is an open-source and web-based application for text analysis. There are many text visualization methods provided in Voyant Tools for users to gain insights into the uploaded text. However, Voyant Tools is not suitable for addressing the problem in this thesis due to two limitations. The first limitation is that there is a lack of data management function in Voyant Tools for managing about 30, 000 learning statements covering two sections, five assignments in three years. The other limitation is that Voyant Tools is unable to extract learning statements from the document submitted by students. In Chapter 3, the foundation of tools and algorithms is proposed to construct a text mining framework for analyzing students' structured reflection and visualizing the mining results. In Chapter 4, the text mining framework is presented to fills the gap of text mining in the engineering education domain.

2.2 GAP ANALYSIS IN THE LITERATURE REVIEW

The unstructured and heterogeneous textual data is hard to use text mining methods to analyze because it is impossible for text mining methods to deal with complex and confused data. Learning statement is defined as a triple structured sentence for students to complete, which are nature language needs to be cleaned from the program perspective. In this thesis, the first gap between the research question and expected goal is dealing with the original textual data available. The methods proposed in the hypothesis verify expected results in the thesis from the theoretical structure validity. In the hypothesis, nature language processing methods are used to formalize these heterogeneous textual contents. Details of the data cleaning tools and corresponding methods are introduced in Section 3.2 and 4.3. This is Gap 1 of this thesis to resolve the problem of data utility in the original textual documents.

[1] https://voyant-tools.org/

Gap 1:

Formalization of unstructured and heterogeneous textual documents

After cleaning the textual data, there are different text mining methods can be used to deal with the cleaned data. There is another question that how to choose best suitable text mining methods to get the insightful results. The selection of text mining methods depends on the expectation for researchers with the data and related backgrounds. For example, sells expect to get the mining results of customers' comments to improve the quality and purchase of products. In this thesis, the gap of transforming textual contents into meaningful results is the generation of text mining methods. Details of text mining algorithms and methods are proposed in Section 3.4 and 4.4. Through the operation of chosen text mining methods, meaningful results will be presented in Chapter 6. Gap 2 of the research question in the thesis is shown in below.

Gap 2:

Generation of meaningful results from the text contents

Intuitive visualization results help researchers and users discover the patterns in the original data. The text visualization methods is similar with statistical methods, otherwise different data source. The textual contents is hard to summarize the inner meaning because nature language is impossible to do the statistic work. With different text mining methods and visualization methods, there are different representations from the original data. Researchers can utilize different graph to get different suggestions. The visualization tools and methods are presented in Section 3.5 and 4.5. With these chosen visualization methods, many visualization results are drawn in Chapter 6. Meaningful reflections and comments are generated by these results.

Gap 3:

Intuitive representation of the text mining results

2.3 THE HYPOTHESIS BASED ON THE GAPS

2.3.1 The Presentation of Hypothesis

From Gap 1 in last section, unstructured and heterogeneous textual data is impossible for the text mining program to deal with and execute. At the meantime, there are over 30,000 learning statements students proposed in past three years 2017, 2018 and 2019. It is a huge amounts of data to deal with for instructors and researchers. In the text mining framework, a function is developed to configure the extraction rules and general cleaning methods. The extraction rules are configured to extract the indicated parts from textual documents, such as students' assignments, learning essay. Hypothesis 1 is proposed to solve the sub question 1 in the thesis, what is the appropriate method for handling large amounts of text data in the program. The function which is used to transform the original unstructured data into cleaned data helps the text mining program deal with the large amounts of data and get the meaningful mining results. As mentioned in the gap analysis section, the data cleaning function will be detailed described in Section 3.2 and 4.3. With Hypothesis 1, the sub question 1 could be resolved for future analysis.

Hypothesis 1:

A function for users to configure extraction rules can support users to deal with the large amounts of learning statements data.

Different text mining algorithms result different insights for users or instructors in learning statements. For example, word frequency algorithm provides the highest frequent words which also are most important words in students' reflection. The most important key words help instructors locate students' focusing on each stage of the course. And text network algorithm provides the connection results between different words in students' learning statements. These results present the semantic meaning of the textual data. The word pair of 'flexible action' reflects students' positive attitude to their design project. Therefore, Hypothesis 2 is proposed that the text mining program integrate different text mining algorithms which generate different mining results from different perspectives to facilitate comprehensive mining of the learning statements.

Different text mining algorithms are presented detailed in Section 3.4 and 4.4. With Hypothesis 2, Sub question 2 could be resolved to get meaningful results for future visualization.

Hypothesis 2:

Integrating multiple text mining algorithms in a program can facilitate comprehensive mining of the learning statements from different perspectives.

Visualization graphs help users and instructors intuitively centralize the apparent features of the graphs. These visualization graphs present the mining results from different perspectives. Users or instructors gain insights from different visualization graphs. Histogram ranks the frequency of words, and highest frequency words reflect the focusing of the original textual data. Word cloud also shows the higher frequency words by enlarging their size. These two visualization tools both help instructors to compare these visualization results with the expected results. Other visualization tools reflect other insightful conclusions. Details of these visualization results are presented in Chapter 6. The description of the visualization methods is in Section 3.5 and 4.5. With Hypothesis 3, sub question 3 could be resolved for instructors to gain insights or create knowledge for improving the course.

Hypothesis 3:

Using visualization tools such as word cloud, histogram, text network, and radar chart can help instructors gaining new knowledge or insights from the learning statements.

2.3.2 The Relation between Questions and Hypothesis

Different hypothesis help solve the corresponding sub questions. The sub questions extend from the primary research question in the thesis. Three hypothesis which relate the sub questions construct the functions of the text mining framework. In Figure 2.1, the relationships between between the questions and hypothesis are illustrated.

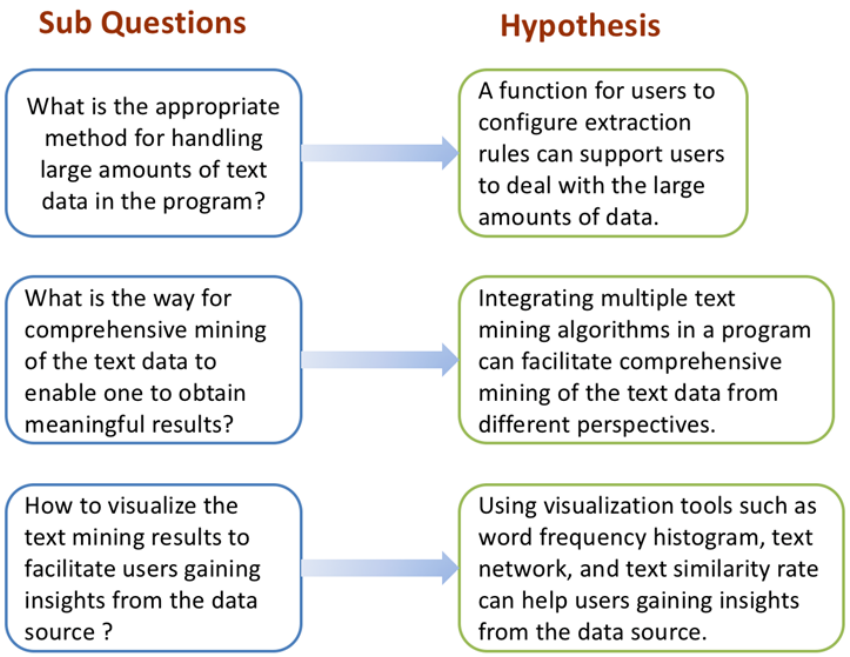
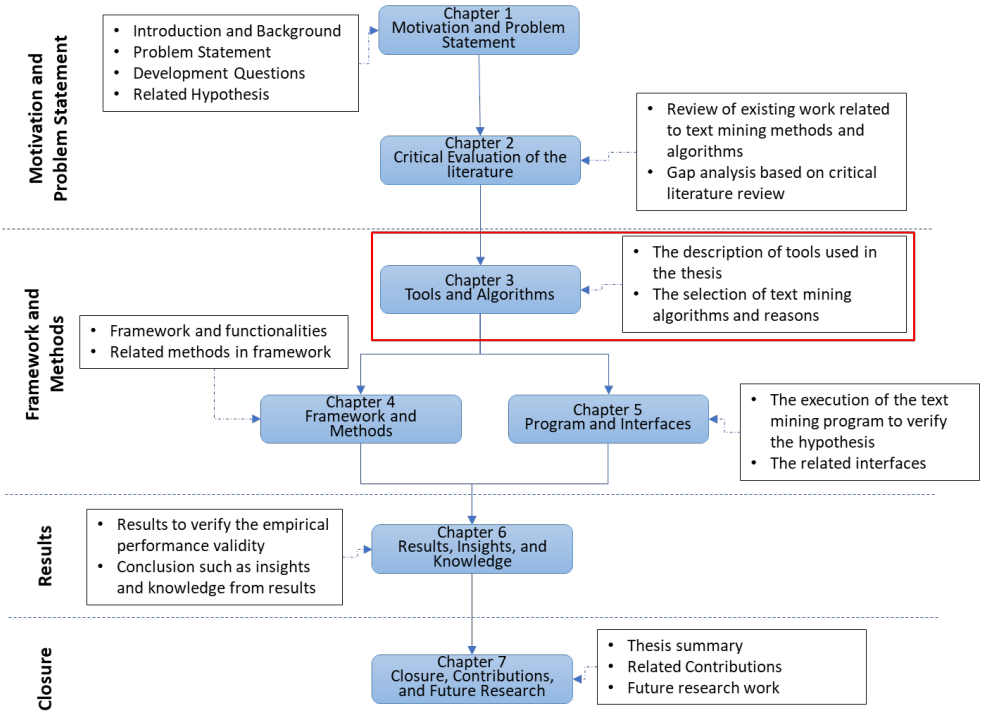


Figure 2.1 The Relation between Questions and Hypothesis

CHAPTER 3 FOUNDATION: TOOLS AND ALGORITHMS



In Chapter 2, literature related to engineering design education and text mining is critically evaluated, and based on the evaluation three research gaps as well as the associated hypothesis are identified. In this chapter, the foundational tools and algorithms that are important for filling the research gaps are presented. The role of this chapter is to identify the key elements for constructing a framework with theoretical structural validity, which maps to Quadrant 1 of the Validation Square. The foundational tools and algorithms are identified mainly for addressing four functions, namely, data cleaning, data management, text analysis and result visualization. For data cleaning, stemmer algorithms and stop words filtering methods are discussed in Section 3.2. Relational database tools for data management are discussed in Section 3.3. In Section 3.4, text analysis algorithms including Word Frequency Algorithm, Text Similarity Algorithm, and Text Network Algorithm are discussed. In Section 3.5, visualization tools including Word Cloud, Radar Chart, and Text Network are presented.

3.1 TOOLS AND ALGORITHMS TO SUPPORT TEXT MINING IN THE THESIS

In common, we usually search for appropriate tools to solve the problem and get the answers. In this thesis, text mining methods are used to answer the primary development question: How can instructors leverage assessment instruments in design, build, and test courses to simultaneously improve student outcomes and assess student learning well enough to improve courses for future students? In the details of text mining methods, we should consider how we can extract useful components in a huge amount of text content? What are the suitable methods to save these text contents for future use and selection? What are the tools that can be used to analyze these textual contents? And How can we visualize the mining results? The different functions of text mining methods are shown in Figure 3.1. With these considerations, there are corresponding tools to realize in the thesis, which will be detail described in Section 3.2, 3.3, 3.4 and 3.5.

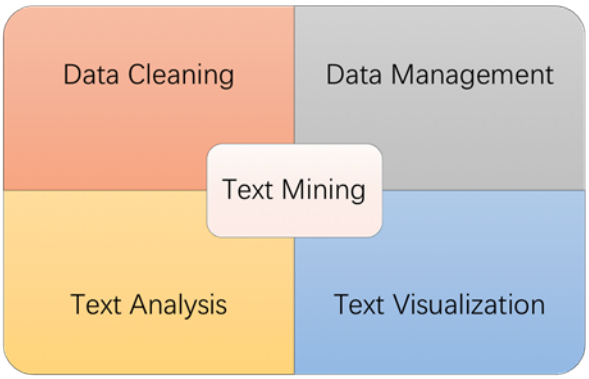


Figure 3.1 The Functions for Text Mining

Table 3.1 is the proposed tools and algorithms used in different functions. Firstly, in the function of data cleaning, the tool of stemmer is used to transit the original words into their root words for statistic and analysis. The tool of stop words is used to filter the useless words in the text contents, such as a, the, for, of, and so on. Through data cleaning, key components are extracted from the text contents. For data storage, a relational database is used to save the text contents and extracted keywords. The relational database is used to index the text and search the data through some conditions. In the function of text analysis, there are different text mining algorithms used to compute the text contents, including Word Frequency Algorithm, Text Similarity Algorithm, Text Network, Latent Dirichlet Allocation Algorithm, Knowledge Graph. These algorithms are using to get the digital results for visualization. In the function of Text Visualization, different tools are used to visualize the text mining results. Word Cloud and Histogram are using to show the

distribution of keyword, which are easily found out the most important words in the text contents. A radar Chart is using to display different attributes of a document. For Text Network, there are connections among the words in the text contents. And Scatter Text tool is used to distinguish the inconsistencies and consistency between two different text contents. Table 3.1 is the statistical results of the proposed tools and algorithms used in different functions. These tools and algorithms will be introduced in the next sections.

Table 3.1 The Tools used in the Thesis

Functions	**Proposed Tools and Algorithms**	**Utility**
Data Cleaning	-Stemmer	Words Reduction
	-Stop words	Words Filtering
Data Management	-Relational Database	Data Indexing
Text Analysis	-Word Frequency	The counts of keywords
	-Text Similarity	The similarity between text
	-Text Network	The connection among words
	-LDA	The topics in the documents
	-Knowledge graph	The semantic relationship among concepts
Text Visualization	- Word Cloud and Histogram	The distribution of keywords
	- Radar Chart	The attributes of a document
	- Text Network	The connection strength between words
	- Scatter Text	The consistency between two sectors

3.2 DATA CLEANING TOOLS

3.2.1 The Tool of Stemmer

A stemmer is a tool for reducing inflected (or sometimes derived) words to their word stem, base or root form—generally a written word form [43]. A stemming algorithm should first identify related strings such as learning, learned, and learner, and then, reduce these strings to their stem word learn. It should be noted that the stem need not be identical to the morphological root of the word. For example, a stemmer can reduce Strings argue, argued, argues, and arguing to the stem argu, which is not identical to the morphological root argue. It is usually sufficient that related words map to the same stem, even if this stem is not in itself a valid root.

Stemming algorithms have been widely studied in computer science, especially for information retrieval. Many search engines treat words with the same stem as synonyms as a kind of query

expansion, a process called conflation [44]. A stemming algorithm typically includes three parts: a lookup table, a set of rules, and a matching mechanism. A lookup table is a table where the stemmer and all the inflected forms are listed. Using a lookup table, it is simple, fast, and easy to handle exceptions. However, the shortcoming is that we need to manually maintain the lookup table, and continuously add those new unhandled words into the table which may results in the table becoming larger and larger. The stemming rules are used to define how the inflected words are converted to their stems. Some examples of the rules are as follows:

- if the word ends in ‘ed’, remove the ‘ed’.
- if the word ends in ‘ing’, remove the ‘ing’.
- if the word ends in ‘ly’, remove the ‘ly’.

Given an input word form, the algorithm will find its root form according to the rules. A matching mechanism is used to match the words in the document to the related words in the lookup table or the rules and generate the stems as the output. Porter Algorithm is using simpler rules to match the stems for the documents. Porter Algorithm realizes a significant reduction in the complexity of the rules associated with suffix removal, which reduces to 294 suffixes [45]. And Porter Algorithm uses a unified approach to handle with textual context. The algorithm is continuing to be employed in many applications, which already extends far beyond to its original intended using.

Suffix stripping approaches develop the advantages that it is much simpler to maintain than other regular algorithms, in the challenges of morphology suffix stripping rules [46]. Suffix stripping approaches are somewhere performed poorly to deal with exceptional stripping rules (such as ‘got’ to ‘get’). This is because not all parts of speech have such a well formulated set of rules for suffix stripping approaches. Lemmatisation Algorithm is going to resolve the problem.

A more complex tool to transfer the stem for a word is Lemmatisation Algorithm [47]. The algorithm firstly discovers the part of speech for a word before stemming. Secondly, Lemmatisation Algorithm provides different stemming rules for different parts of speech of words. The part of speech should be first detected before stemming the words directly, because some stemming rules are different for one word with different parts of speech. For example, the word ‘slides’ is detected as noun, and the stem rule is removing the ‘s’. but when detected as verb, the stem rule is removing the ‘ed’. Lemmatisation Algorithm has highly probability to obtain the correct part of speech and stems. The conclusion is that if the selected stemmer tool is able to

provide more information about the original words, the tool can apply more accurate stem results for words to translate. In the thesis, Lemmatisation Algorithm is used to clean the textual data.

3.2.2 The Tool of Stop Words Filter

Stop words are words which are filtered out before or after processing of natural language data (text) [48]. For example, in the sentence, 'I learned a tool in last lecture', the words a, in are meaningless for understanding the semantics of the sentence and should be filtered out. Any group of words can be chosen as the stop words for a given purpose. For some search engines, stop words are some of the most common, short function words, such as 'the', 'is', 'at', 'which', and 'on'. Other tools remove some of the most common words—including lexical words, such as 'want'—from a query in order to improve performance (the word want is meaningless in a query statement). The stop words list includes two parts: general stop words and specified stop words. Before using the stop words filter tool, the preprocessed paragraphs need to be segmented into different words or phrases based on the language rules. The segmented words or phrases group is ordered to match the configure stop words list. The matched words or phrases are defined as stop words in the original paragraphs and removed from the words or phrases group. The new processed words or phrases group is combined again to construct the cleaned paragraphs.

3.3 DATA MANAGEMENT TOOLS

For using tools to store structured data, relational database is a useful tool to help data save and search easily. In the relational database, data is organized into one or more tables of columns and rows, with a pre-defined unique key identifying different data [49]. Rows are also called records or tuples. Columns are also called attributes. Generally, each table/relation represents one "entity type" (such as student or course). The rows represent instances of that type of entity (such as "Lee" or "AME4163") and the columns representing values attributed to that instance (such as name or id). A relation is defined as a set of tuples that have the same attributes. A tuple usually represents an object and information about that object. Objects are typically physical objects or concepts. A relation is usually described as a table, which is organized into rows and columns. All the data referenced by an attribute are in the same domain and conform to the same constraints. In the relational database, the values of entity reflect the results of defined attributes.

The relational database specifies that the tuples of a relation have no specific order and that the tuples, in turn, impose no order on the attributes [49]. Applications access data by specifying queries, which use operations such as select to identify tuples, project to identify attributes, and join to combine relations. Relations can be modified using the insert, delete, and update operators. New tuples can supply explicit values or be derived from a query. Similarly, queries identify tuples for updating or deleting. Tuples by definition are unique. If the tuple contains a candidate or primary key then obviously it is unique; however, a primary key need not be defined for a row or record to be a tuple. The definition of a tuple requires that it be unique but does not require a primary key to be defined.

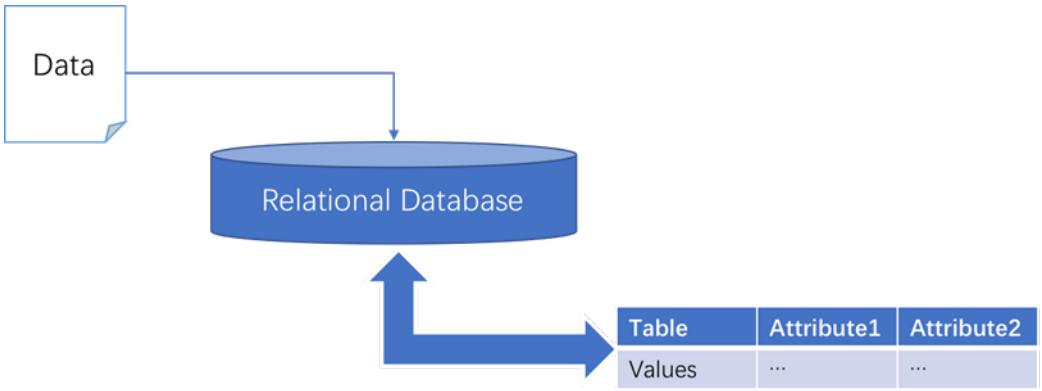


Figure 3.2 The Relational Database

3.4 TEXT ANALYSIS ALGORITHMS

3.4.1 Word Frequency Algorithm

There may be many patterns hidden in the text contents stored (or accumulated) in the database. One of these patterns is that the occurrence frequency of some words are relatively high in the text contents. Other patterns include the correlation of different text contents with different tags. In order to discover these patterns, the text is quantified by using Word frequency (WF) Algorithm.

$$\textbf{Word Frequency: } WF(t,D) = N(t,D)/\|D\| \tag{3.1}$$

wherein, t stands for a specific term, D stands for a specific document that contains Term t, $N(t,D)$ stands for the number of times Term t occurs in Document D, and $\|D\|$ means the total number of terms contained in document D.

3.4.2 Text Similarity Algorithm

By using Text Similarity Algorithm, 1) combine the text contents into one document (denoted as D_1), 2) combine other compared text contents into another document (denoted as D_2), and 3) compute the similarity between these two documents (D_1 and D_2).

The equation for computing the similarity is the cosine distance, given by

$$Sim(D_1, D_2) = cos < Vector(D_1), Vector(D_2) > = \frac{Vector^T(D_1) * Vector(D_2)}{\|Vector(D_1)\| * \|Vector(D_2)\|} \quad (3.2)$$

where $Vector(D_1)$ and $Vector(D_2)$ are the two vectors representing Documents D_1 and D_2. The elements of a document vectors are the weights of the keywords occurred in the document, represented as

$$Vector(D) = \left[W_{t_1}, W_{t_2}, \dots W_{t_i}, \dots W_{t_n}\right] \; i \in n \quad (3.3)$$

where W_{t_i} stands for the weights of Term t_i in Document D. The weight of a term is calculated using the Term Frequency – Inverse Document Frequency (TF-IDF), expressed as

$$W_t = TF(t, D) * IDF(t) \quad (3.4)$$

where $TF(t, D)$ and $IDF(t)$ stand for the frequency and inverse document frequency of Term t occurs in Document D, respectively. $TF(t, D)$ is calculated as follows:

$$TF(t, D) = N(t, D)/\|D\| \quad (3.5)$$

where $N(t, D)$ stands for the number of times Term t occurs in Document D, and $\|D\|$ means the total number of terms contained in document D. Inverse Document Frequency (IDF) is typically used to distinguish the keywords in different documents so that those more representative keywords in a particular document can have higher weights. If TF is simply used as the weight of a specific Term t in Document Di, then in the case where students are well aligned with the instructors, those critical concepts (e.g., “team”) are likely to appear more frequently. However, other noise concepts (e.g., “design”) that are common in all the assignments may also appear frequently in Document Di, which would confuse the conclusion that the overall alignment is attributed to the alignment of those critical words or the noise concepts. IDF, which denotes the uniqueness of Term t to Document Di, can help us distinguish critical concepts and noise concepts

by assigning different weights to them. Therefore, the weight of Term t is calculated with considering IDF in addition to TF, namely, $W_t = TF(t, D) * IDF(t)$.

IDF is calculated as follows:

$$IDF(t) = 1 + \log\left(\frac{N}{DF(t)}\right) \tag{3.6}$$

wherein N means the total number of documents and $DF(t)$ stands for the number of documents that contain Term t.

3.4.3 Text Network

A text network consists of nodes and edges. The nodes represent words that are extracted from the learning statements. The edges represent links between word nodes. The size of nodes reflect the total connection frequency of the corresponding word. The more frequently a word occurs in students' learning statements, the bigger the size of that word node will be. The weight together with length of an edge reflect the closeness between two word-nodes.

The weight and length of an edge is calculated by the equations as follows:

$$Weight_{wi,wj} = \sum \frac{1}{Distance_{ls}(wi,wj)} \tag{3.7}$$

$$Length_{wi,wj} = \text{avg}(Distance_{ls}(wi, wj)) \tag{3.8}$$

ls in Equations 3.7 and 3.8 denotes one of the learning statements. Weight and length are two attributes of an edge. Weight reflects the connection frequency between two words, and length reflects the average distance between two words in corresponding learning statements.

3.5 TEXT VISUALIZATION ALGORITHMS

3.5.1 Word Cloud

In the language of visual design, word cloud is one visualization method of weighted words, as commonly used on geographic maps to represent the relative size of words. The specific visual form and common use of the term "word cloud" rose to prominence in the first decade of the 21st century as a widespread feature of early Web 2.0 websites and blogs, used primarily to visualize the frequency distribution of keyword metadata that describe website content, and as a navigation aid.

Word cloud method and ambivalence about its utility as a web-navigation tool led to a noted decline of usage among these early adopters. A second generation of software development discovered a wider diversity of uses for word clouds as a basic visualization method for text data. Word clouds are typically represented using inline HTML elements. The words can appear in alphabetical order, in a random order, they can be sorted by weight, and so on. Sometimes, further visual properties are manipulated in addition to font size, such as the font color, intensity, or weight. Most popular is a rectangular tag arrangement with alphabetical sorting in a sequential line-by-line layout. The decision for an optimal layout should be driven by the expected user goals. Some prefer to cluster the words semantically so that similar words will appear near each other or use embedding techniques such as tSNE to position words.

Figure 3.3 A Visualized Result Using Word Cloud

Word cloud visual taxonomy is determined by a number of attributes: word ordering rule (e.g. alphabetically, by importance, by context, randomly, ordered for visual quality), shape of the entire cloud (e.g. rectangular, circle, given map borders), shape of word bounds (rectangle, or character body), tag rotation (none, free, limited), vertical tag alignment (sticking to typographical baselines, free). A word cloud address problem of modeling and controlling aesthetics, constructing a two-dimensional layout of words, and all these would be done in short time on some suitable platforms.

3.5.2 Radar Chart

A radar chart is a graphical method of displaying multivariate data in the form of a two-dimensional chart of three or more quantitative variables represented on axes starting from the same point. The relative position and angle of the axes is typically uninformative, but various heuristics, such as algorithms that plot data as the maximal total area, can be applied to sort the variables (axes) into relative positions that reveal distinct correlations, trade-offs, and a multitude of other comparative measures. The radar chart is also known as web chart, spider chart, spider

web chart, star chart, star plot, cobweb chart, irregular polygon, polar chart, or Kiviat diagram. It is equivalent to a parallel coordinates plot, with the axes arranged radially.

The radar chart is a chart and/or plot that consists of a sequence of equiangular angle, with each angle representing one of the variables. The data length of an angle is proportional to the magnitude of the variable for the data point relative to the maximum magnitude of the variable across all data points. A line is drawn connecting the data values for each angle. This gives the plot a star-like appearance and the origin of one of the popular names for this plot. The star plot can be used to answer the following questions:

- Which observations are most similar, i.e., are there clusters of observations?
- Are there outliers?

Radar charts are a useful way to display multivariate observations with an arbitrary number of variables. Each star represents a single observation. Typically, radar charts are generated in a multi-plot format with many stars on each page and each star representing one observation. There is no separation into foreground and background variables. It is easier to see patterns in the data if the observations are arranged in some non-arbitrary order.

Figure 3.4 A Visualized Result Using Radar Chart

Radar charts are primarily suited for strikingly showing outliers and commonality, or when one chart is greater in every variable than another, and primarily used for ordinal measurements – where each variable corresponds to "better" in some respect, and all variables on the same scale. Conversely, radar charts have been criticized as poorly suited for making trade-off decisions – when one chart is greater than another on some variables, but less on others. Further, it is hard to visually compare lengths of different spokes because radial distances are hard to judge, unlike line chart to show the trends in time series.

3.5.3 Text Network

Text network is used to represent the connectivity and semantics among the words as a graph in a two-dimensional space [50]. The visualization results of text network could clearly reflect the text structure with a Force Atlas algorithm to represent [51]. The force-layout clustering algorithm is fulfilled to distract different clusters in the text network [52]. The realization of two algorithms in the text network provides more readable representation results of the graph.

Figures 3.6 shows a graph representation of the 2-word connectivity text network. To provide a more meaningful results, the sizes of nodes/words are ranked based on their connectivity frequency. The higher the connectivity frequency of the word is, the more central position and bigger size is used to show the node/word. This node/word plays a role as a junction for communication within the text network. Connectivity distance (or length) is different from the node's connectivity frequency (or width). For example, it is possible that a node/word is connected to a lot of other nodes/words in a certain cluster, but the distances of these connectivity are longer than anticipated. With reflecting the attribute of connectivity length, the relation of different word-pairs performances well in the text network, which cannot be detected in the results of word cloud.

Connectivity distance shows the relations of connectivity for the appearing words, while connectivity frequency shows the variety of word-pairs in the appearing words. In the thesis, the attributes of connectivity frequency and connectivity distance are both important to be represented in the graphs of text network, which reflect the connectivity and semantics of the textual data, just like the graph in Figure 3.6.

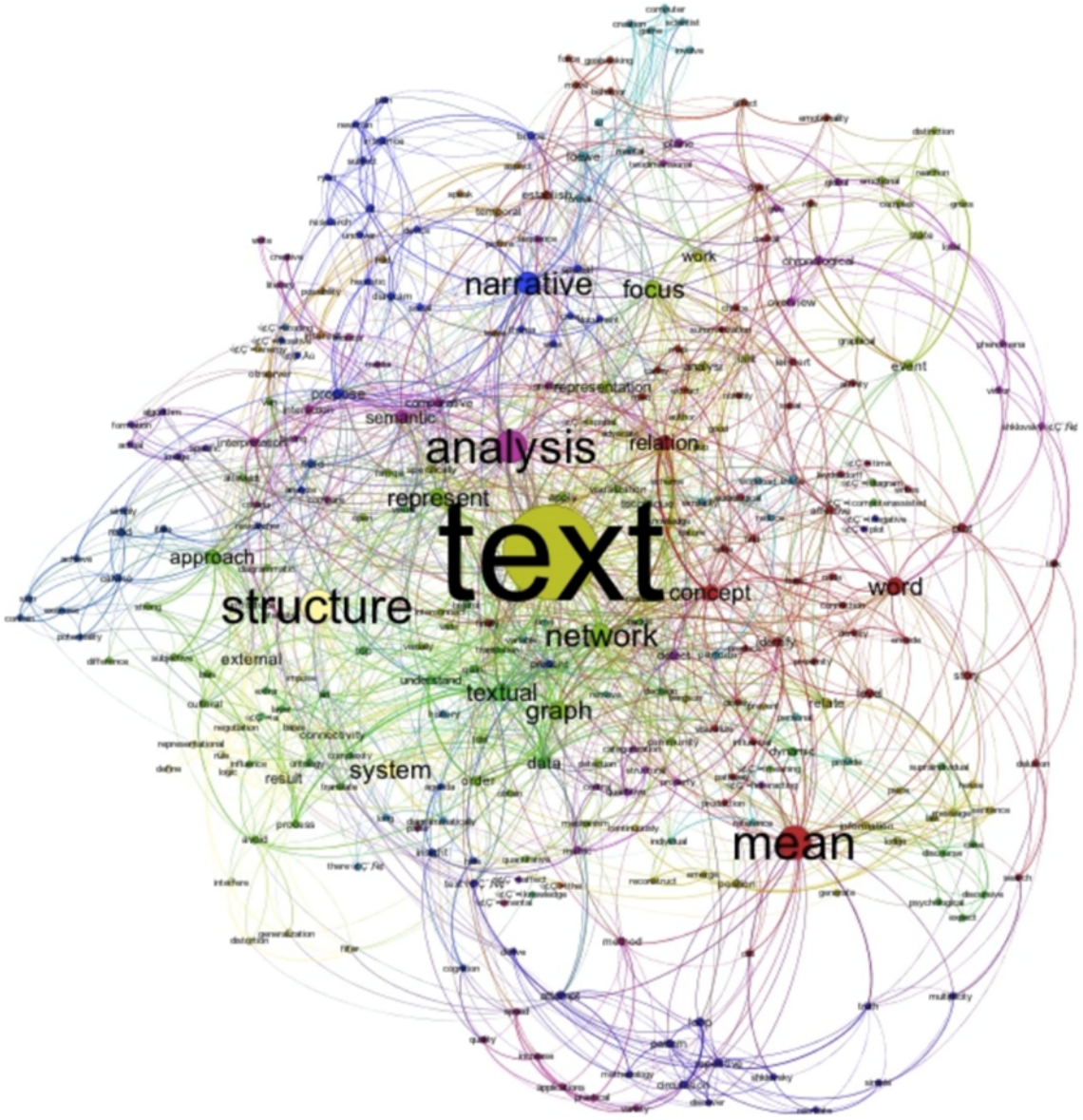


Figure 3.5 A Visualized Result Using Text Network

3.6 ON VERIFICATION AND VALIDATION – THEORETICAL STRUCTURAL VALIDITY (TSV)

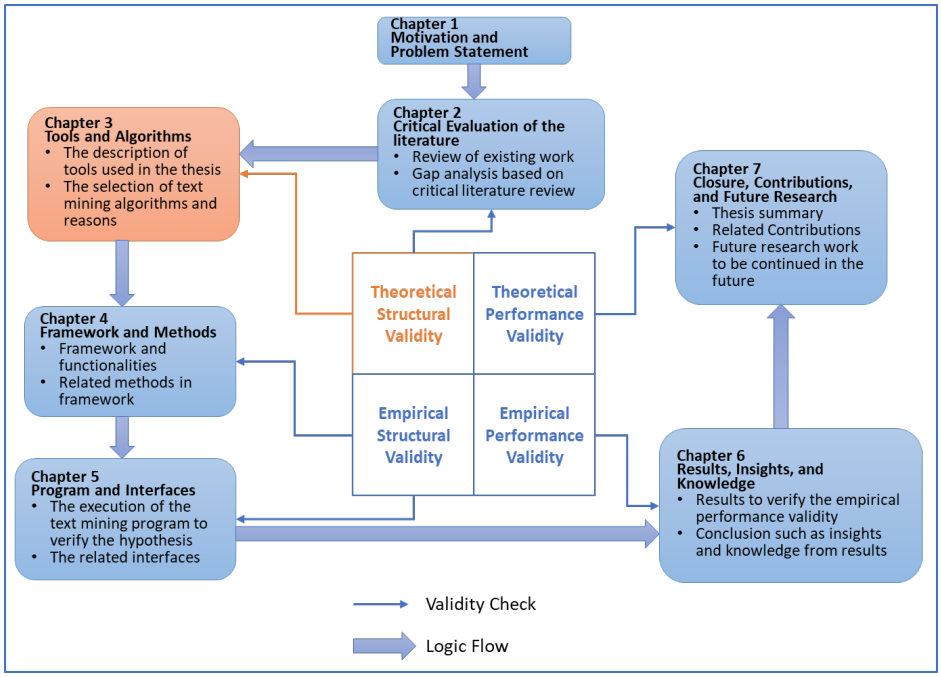


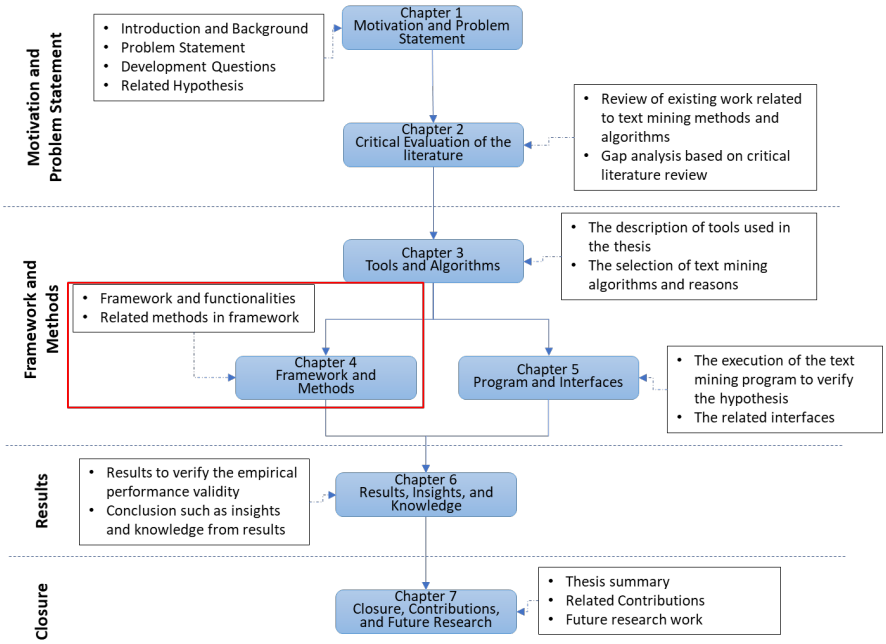
Figure 3.6 Validation Square of Chapter 3

In this chapter, the tools are used in the text mining framework and the relevant algorithms, including the tools for data formalization, data storage and graph visualization. The tools used in the text mining framework and the relevant algorithms help to verify the question in Theoretical structural validity – *Is the design method internally consistent?*

- Before introducing the tools to answer the question, It is presented the background and problem statements in Section 1.1 and 1.2. There are the relevant hypothesis logically formulated to cover the problem statements in Section 1.3. In Chapter 1, the requirements of the development question are described clearly.
- In Section 3.2 and 3.3, it is discussed the developed tools for data cleaning, data management. There are the application domain and limitations for the concurrent tools. I will choose appropriate tools to use in the text mining framework.
- In Section 3.4 and 3.5, it is discussed the application domain and limitations for the concurrent text mining algorithms and visualization tools. There are different algorithms

and tools to analyze learning statements to gain different insights for instructors. these text mining algorithms and visualization tools are used to answer our development question.

CHAPTER 4 A TEXT MINING FRAMEWORK FOR ANALYZING STUDENTS' LEARNING STATEMENTS



In Chapter 3, the foundational tools and algorithms for constructing the text mining framework are proposed to realize the functions of the framework that help answer the corresponding sub development questions. In this chapter, the detailed text mining framework and the related functions are presented. The role of this chapter is to identify the methods used in the text mining framework with empirical structural validity, which maps to Quadrant 2 of the Validation Square. Overview of the text mining framework is presented from users' perspective and functions' perspective. The methods for cleaning triple structured learning statements are presented in Section 4.3. Mining method to compute the textual data is discussed in Section 4.4. Different visualization methods used in the framework are presented in Section 4.5.

4.1 OVERVIEW OF THE TEXT MINING FRAMEWORK

The text mining framework from user's perspective is illustrated in Figure 4.1. Data contributors are students or teaching assistants who submit or collect original learning statement documents, and then upload them to the framework for analysis. To distinguish the documents in the program,

data contributors need to annotate the documents when uploading. Researchers are instructors who are interested in the knowledge hidden in the learning statements. They can review the results (numbers, graphs, word clouds, etc.) given by the text mining program and gain insight. A user can be both a data contributor and a researcher based on his/her interests. In Section 4.2, the text mining framework is described with details.

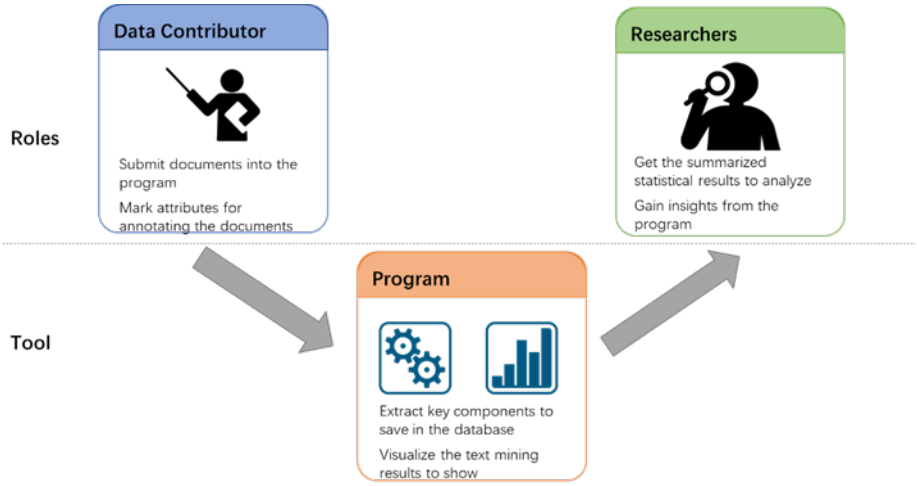


Figure 4.1 An Overview of the Text Mining Framework from User's Perspective

4.2 THE FRAMEWORK AND RELATED FUNCTIONALITIES

4.2.1 The Text Mining Framework

A schematic of the text mining framework is shown in Figure 4.2. The framework consists of three parts: data contributors, program, and researchers. In the framework, the actions of data contributors include 1) submitting original documents to the program, 2) setting up the matching rules for the extraction of learning statements from the original documents, and 3) annotating relevant attributes to the uploaded documents. These text documents are intended to generate the corresponding visualization results in the program. The program has four key functionalities, namely, data cleaning, data management, text analysis, and results visualization. Data cleaning is used to extract key words from the raw textual contents. Data management is to save the cleaned data into the database using structured formats. Text analysis is to analyze the stored textual data and discover the hidden patterns using various of algorithms such as word frequency, text similarity, and connection, etc. Finally, the discovered patterns will be visualized using different types of graph or chart to facilitate researchers gaining insights from the textual data. These

visualization results can facilitate researchers interpreting the original text contents, answering their research questions, and creating new knowledge.

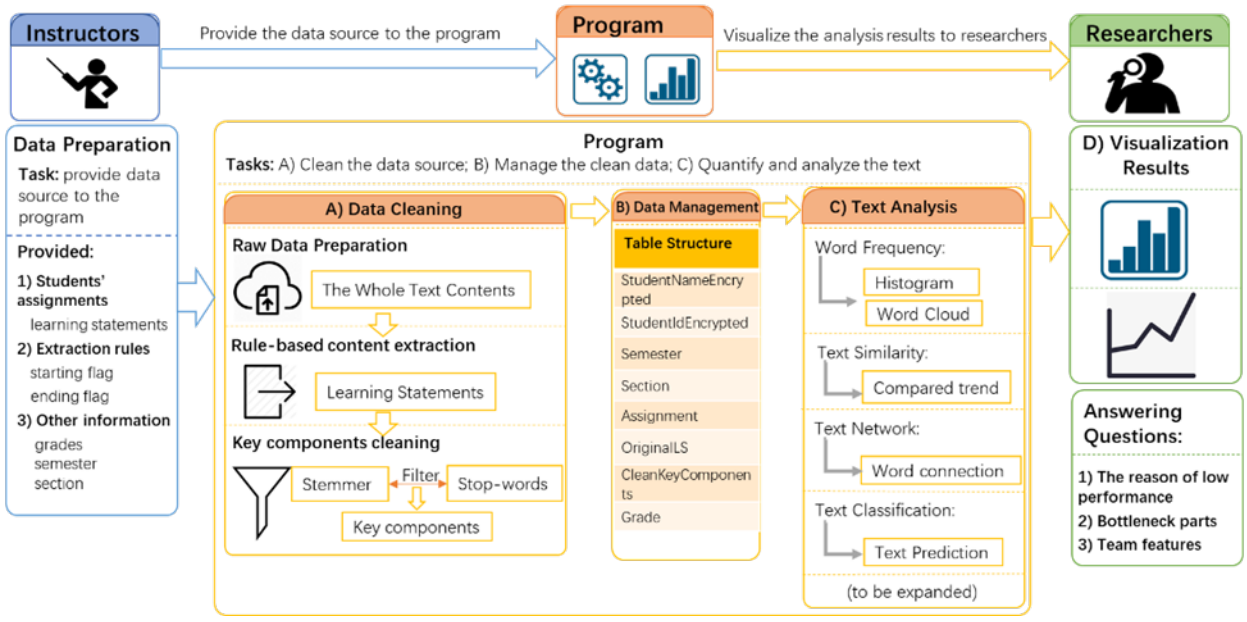


Figure 4.2 The Text Mining Framework for Quantification of Students' Learning Statements

4.2.2 The Functionalities in the Framework

I describe a text mining framework for analyzing the learning statements in Section 4.1 and 4.2.1. The framework consists of a program and two roles, namely, data contributors (i.e., instructors) and researchers (i.e., educators). The data contributors' actions include submitting original documents to the program, setting up the matching rules for the extraction of learning statements from the original documents, and annotating relevant attributes to the uploaded documents. The role of researchers is to interpret the text mining results generated by the program and gain insights. There are the relevant methods in the four key functionalities of the text mining framework, namely,

- Data cleaning (Block A). Data cleaning is to preprocess the textual contents of a document so that interesting contents are extracted or transformed into a required format.
- Data management (Block B). Data management is to capture and manage key attributes of documents or to structuralize the unstructured text so that the textual data can be accumulated in a database in a reusable and retrievable way.

- Text analysis (Block C). Text analysis is to analyze the stored textual data and discover the hidden patterns using various algorithms such as word frequency, text similarity, text network, etc.
- Results visualization (Block D). Visualization is used to display the mining results in a meaningful way so that researchers can easily understand the patterns in the text.

Visualization results can facilitate researchers interpreting the original text contents, answering their research questions, and creating new knowledge. In this chapter, the relevant tools are introduced such as stemmer, text similarity method (Blocks A, C and D) to enrich the framework's features so as to facilitate researchers gaining insight into students' learning statements. Details of the methods used in each functionalities are discussed in next sections.

4.3 CLEANING OF LEARNING STATEMENTS

The learning statements submitted by students are complete sentences which consist of different parts-of-speech including nouns, verbs, adjectives, adverbs, prepositions, and conjunctions etc. Typically, prepositions and conjunctions are the words used to keep the continuity of sentence, and they don't have practical meaning. What really means something are the nouns, verbs, adjectives, and adverbs. Therefore, there is a need to clean the sentences to retain those meaningful key components. The function of data cleaning in the program consists of three steps, as shown in Figure 4.3.

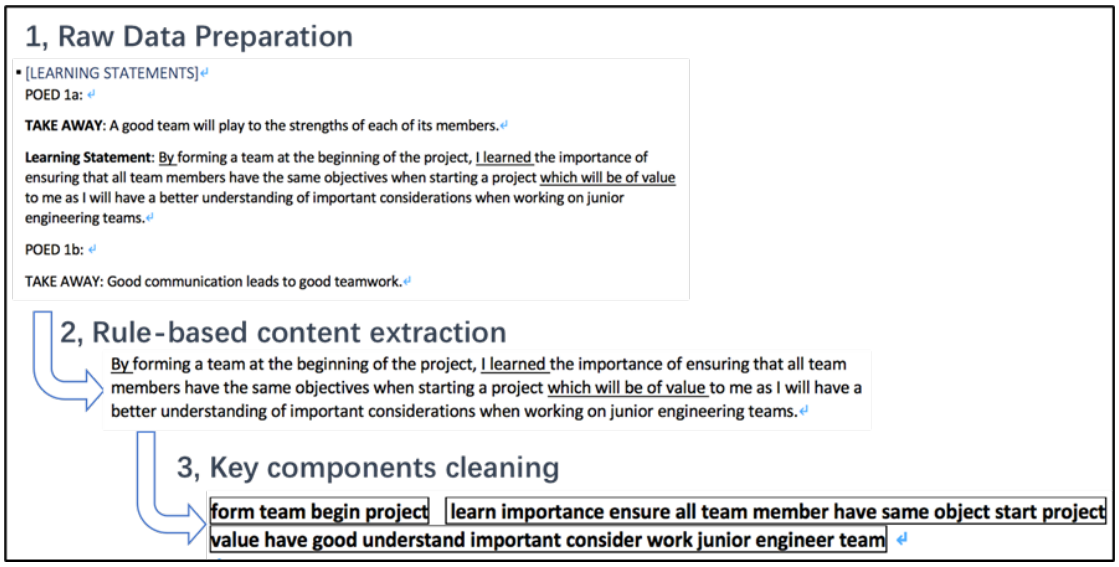


Figure 4.3 The Workflow of the Functionality of Data cleaning

- **Step 1. Raw data preparation.** In this step, students prepare their learning statements using the [Experience|Learning|Value] triplet structure after they attended each lecture or finished each assignment of the course. Below is an example:

  By forming a team at the beginning of the project, I learned the importance of ensuring that all team members have the same objectives when starting a project which will be of value to me as I will have a better understanding of important considerations when working on junior engineering teams.

  It should be noted that students are trained to use the triple structure at the beginning of the semester so that they are skilled at applying it throughout the whole semester. When the learning statements are ready, they are uploaded to the text mining program together with other background information (e.g., lecture information, problem description, solutions, etc.) archived in the same document. The uploading of documents can also be done by teaching assistants who collect the submissions and batch-upload to the program.

- **Step 2. Rule-based content extraction.** As mentioned in Step 1, the documents submitted by data contributors not only include learning statements, but also other background information. There is a need to extract learning statements from the documents. For example, some learning statements may be located in a document as follows:

  …

  Learning Statement: *By forming a team at the beginning* ***…***

  …

  In order to extract the learning statement from the whole document, firstly, it should be located in the position where the statement begins, namely, the phrase "Learning Statement:". This is can be done by setting up the matching rule to match "Learning Statement:", and then extracting the sentence right after it. The extraction is terminated when it reaches a period or a linefeed.

- **Step 3. Key components cleaning.** In this step, the program will automatically filter meaningless words and characters from the textual contents using stemming and stop-words-based method. stemming is the process of reducing inflected (or sometimes derived) words to their word stem, base or root form—generally a written word form. The stem need not be identical to the morphological root of the word, it is usually sufficient that related words map to the same stem, even if this stem is not in itself a valid root. In the text mining program, stemming method is used to convert all the meaningful components to their root form. For example the word "begins" is converted to "begin", the word "better" is converted to "good". In computing, stop words are words which are filtered out before processing of natural language data (text). Stop words are generally the most common words in a language. In the text mining program, stop-words-based method is used to filter meaningless words such as "a", "the", "by", "of", "and", "but", etc.

4.4 MINING OF LEARNING STATEMENTS

There may be many patterns hidden in the learning statements stored (or accumulated) in the database. One of these patterns is that the occurrence frequency of some words are relatively high in the learning statements associated with some particular assignments. For example, "team" and "project" are the high-frequency words in the learning statements associated with assignment of team formation. Another pattern is that the learning statements of those students whose grade are relatively high are typically more relevant (or similar/close) to the requirements (the engineering design principles in the AME4163 course) of the assignments. For example, in the assignment associated with conceptual design, the learning statements of the students who perform well should be more relevant to principles of selection, evaluation, etc. Other patterns include the correlation of the learning statements of the members in a team, and the correlation of the learning statements associated with the sections taught by different instructors in one course etc.

What is really interesting to instructors at the end of the semester is the average degree to which students have internalized the target POEDs after accomplishing a particular assignment. Knowing that degree helps instructors make decisions on whether they need to modify the assignments and the associated lectures so as to improve the internalization of the POEDs. In order to quantify that

average degree, I: 1) combine all the students' learning statement related to the same assignment into one document (denoted as D_1), 2) combine all the target POEDs related to that assignment into another document (denoted as D_2), and 3) compute the similarity between these two documents (D_1 and D_2). The similarity computing process is shown in Figure 4.4.

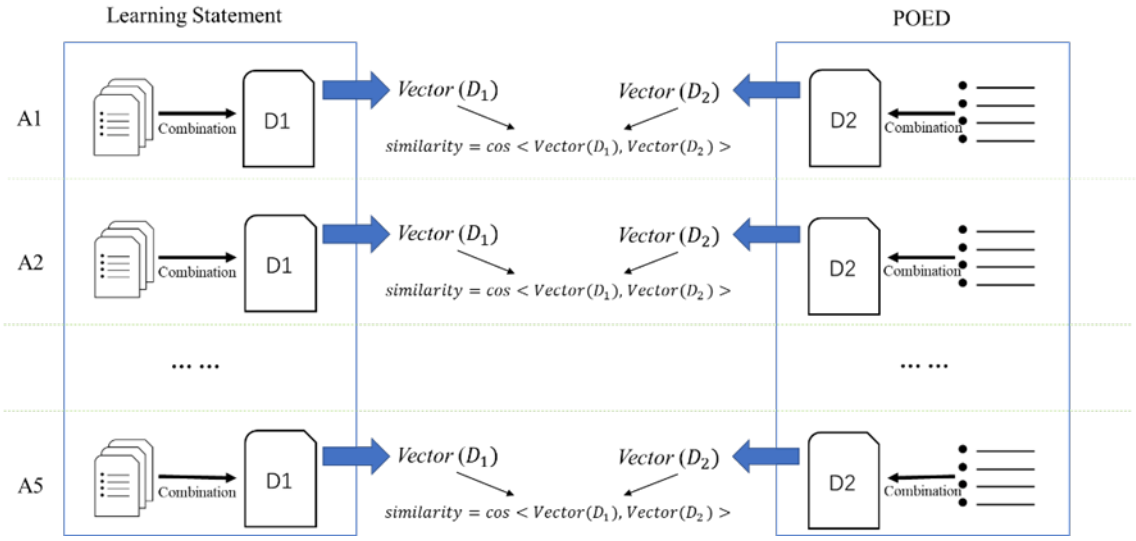


Figure 4.4 Computing the Similarity Between Learning Statements and Target POEDs

In order to discover these patterns, there is a need to quantify the text. In the text mining program several text quantification methods are implemented, such as term frequency (TF), inverse document frequency (IDF, measures how important a term is in a document), word vector, and text similarity, as shown in Equations 1-4, respectively.

$$\textbf{Term Frequency: } TF(t,D) = N(t,D)/\|D\| \quad (4.1)$$

wherein, t stands for a specific term, D stands for a specific document that contains Term t, $N(t,D)$ stands for the number of times Term t occurs in Document D, and $\|D\|$ means the total number of terms contained in document D. Inverse Document Frequency (IDF) is typically used to distinguish the keywords in different documents so that those more representative keywords in a particular document can have higher weights. For example, the term "team" typically occurs in the learning statements related to Assignment 1 but seldom occurred in the learning statements related to other assignments, therefore it should have more weights in the document vector associated with Assignment 1. The term "design" occurs in the learning statements related to almost every assignment; therefore it should have a low weight in the document vectors. If we simply use TF as the weight of a specific Term t in Document Di, then in the case where students are well aligned with the instructor those critical concepts (e.g., "team") are likely to appear more

frequently. However, other noise concepts (e.g., "design") that are common in all the assignments may also appear frequently in Document Di, which would result in the confusion of whether the overall alignment is attributed to the alignment of those critical words or the noise concepts. IDF which denotes the uniqueness of Term t to Document Di, can help us distinguish critical concepts and noise concepts by assigning different weights to them. Therefore when the weight of Term t is calculated with considering IDF in addition to TF, namely, $TI_t = TF(t, D) * IDF(t)$.

$$\textbf{Inverse Document Frequency: } IDF(t) = 1 + \log\left(\frac{N}{DF(t)}\right) \quad (4.2)$$

wherein, N means the total number of documents, $DF(t)$ means the number of documents with Term t.

$$\textbf{TF-IDF: } TI_t = TF(t, D) * IDF(t) \quad (4.3)$$

$$\textbf{Word Vector: } Vector(D) = \left[TI_{t_1}, TI_{t_2}, \dots TI_{t_i}, \dots TI_{t_n}\right] \; i \in n \quad (4.4)$$

wherein, TI_t stands for the TF-IDF computing result of a term in the document, $Vector(D)$ means the vector of the document embodied by all terms' TF-IDF values.

Text Similarity:

$$TS(D_1, D_2) = cos < Vector(D_1), Vector(D_2) >= \frac{Vector^T(D_1) * Vector(D_2)}{\|Vector(D_1)\| * \|Vector(D_2)\|} \quad (4.5)$$

wherein, $TS(D_1, D_2)$ stands for similarity between two texts measured by the cosine value of the two texts.

4.5 VISUALIZATION OF LEARNING STATEMENTS

The quantification results generated using text mining methods need to be displayed in an intuitive way so that the patterns hidden in the learning statements are explicitly shown to researchers for gaining insights. Typically, it is easier for human researchers to gain insights by looking at statistic graphs than simply looking at the numerical results. Commercial office software, such as Microsoft Excel, provide statistic graphs for visualizing numerical results. In Excel, users can input the datasets in the required format, and select the suitable statistic graphs such as line chart, pie chart and dot plot to visualize the datasets. It is convenient to get the graphs, however, there are some disadvantages. One disadvantage is that users have to prepare the datasets according to the required format, which is time-consuming and labor-intensive. Another disadvantage is that the number of statistic graphs provided in Excel is limited, and some graphs are not suitable for visualizing text mining results.

The text mining results of learning statements consist of both words and the associated statistic numbers which are used to indicate frequency, weight, correlation and so on. Graphs such as word cloud and text network are effective for visualizing these text mining results, however, they are not provided in commercial office software. Therefore, these graphs are developed to visualize the text mining results of learning statements.

For the thesis, the visualization results which are generated from different visualization methods show different analysis perspectives of learning statements. There are different focusing and different advantages in different visualization methods. Table 4.1 is the comparison table between different visualization methods.

Table 4.1 The Comparison Between Different Visualization Methods

Visualization Method	**Focusing**	**Advantages**
Histogram	The order of word frequency	Easy to compare the order and word frequency in different sections and years.
Word Cloud	Size of word frequency	The most focusing key word are clear in the graph.
Radar Chart	The comparison in different assignments of the learning statements	Easy to compare same assignment in different years.
Line Chart	The trend in different assignments	Clear discover to see the changes with time series
Text Network	The connections between key words in learning statements	Clear to classify the connections of terms in learning statements

In the text mining program, many useful graphical tools including word cloud, histogram, and text network, etc. are implemented to visualize the text quantification results. Word cloud is a plot that indicates word frequency of a document by the sizes of words (the colors of the words can also be used to indicate some particular type feature of the words), as shown in Figure 4.5. The advantage of word cloud is anchored in that researchers can quickly locate the words with highest frequencies and learn about the emphasis of learning statements. Histogram is another plot to show the emphasis of learning statements in a different way. Compared to word cloud, histogram is used to show the ranking of different words by their frequencies and provide the numeric value of frequency of each word.

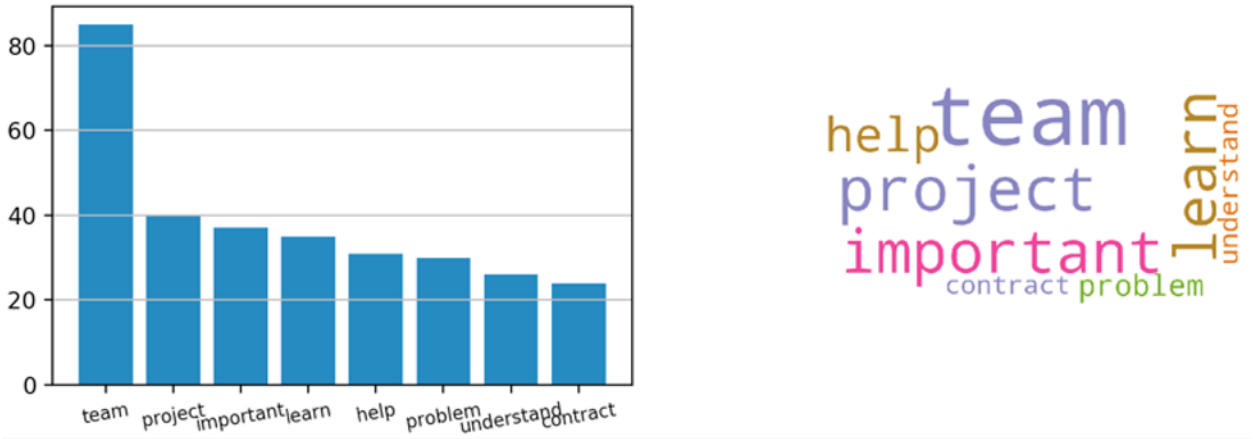


Figure 4.5 The Visualization Methods of Histogram and Word Cloud

Line chart is used to show the evolving trend of a particular feature of learning statements. For example, a line chart is used to indicate how the similarity between students' learning statements and POED evolves as the semester moves ahead. Line chart is a good way to show the trend of numbers, but it is difficult to show the connections among words in the text. Text network is the way to address this issue. Text network consists of words and the correlation between words. In the text network, one can easily find out the most frequent word-pair which indicates students' focus in their learning statements. In word cloud, words are independent and unrelated, but in text network words are connected. In text network, a threshold is used to limit the distance of word-pairs of learning statements. If the distance of a word-pair is farther than the defined threshold, then it will not be extracted for computing in next steps. The threshold is defined based on researchers' prior knowledge. The size of nodes in the text network indicates the frequency of the node in word-pairs. The length of edges in the text network indicates the closeness of the word-pair, and the width of edges indicates the connection frequency of the word-pair. Figure 4.6 is an example of text network with about 10,000 learning statements. The nodes in the graph are too many to display clearly. So the definition of the threshold is important to control the scale of the network. By a text network, instructors can identify the structures in students' learning statements so that they can improve the course accordingly.

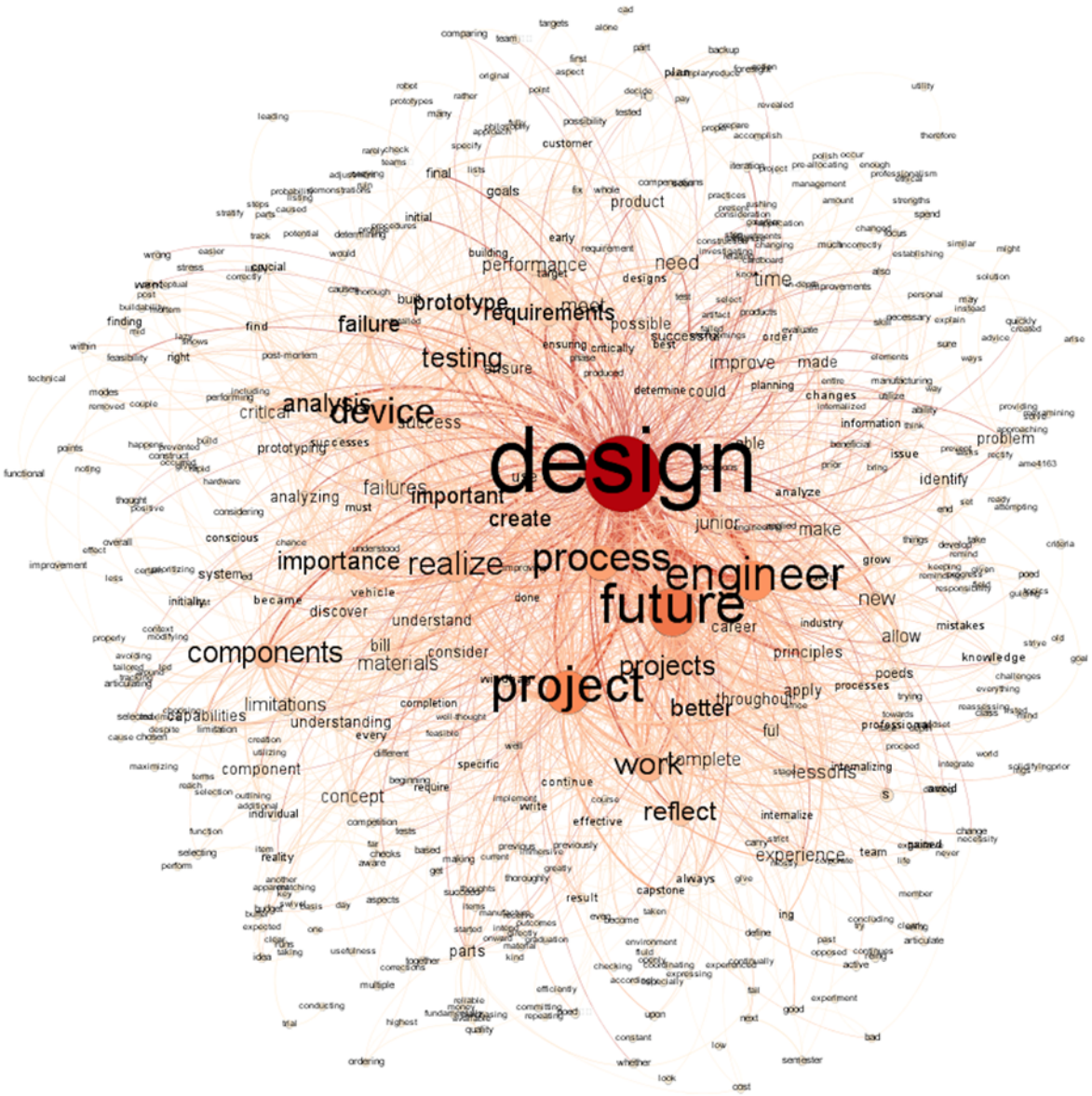


Figure 4.6 The Visualization Methods of Text Network

4.6 ON VERIFICATION AND VALIDATION

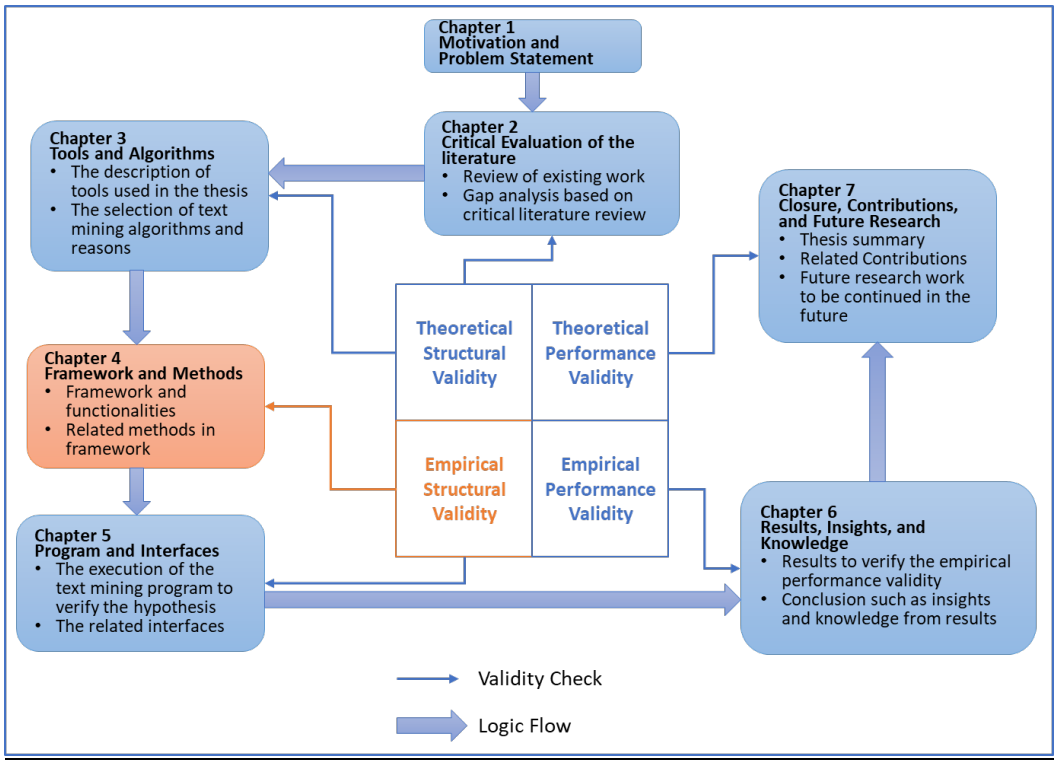


Figure 4.7 Validation Square of Chapter 4

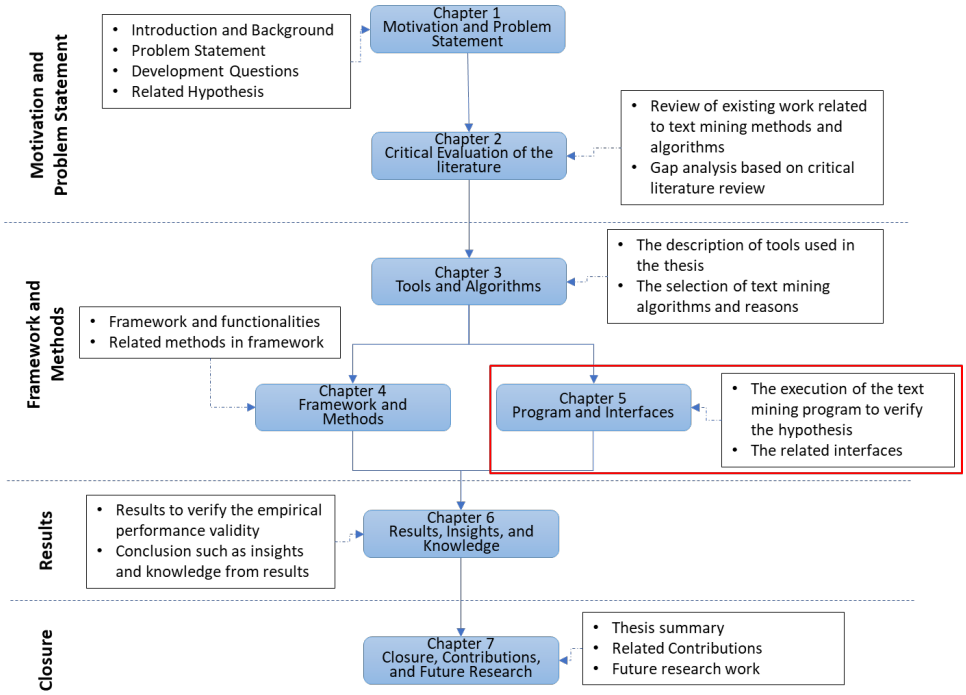
In this chapter, it is presented the text mining framework and related methods, including data cleaning methods, text mining methods, and visualization methods. The text mining framework and the methods help to verify the question in Empirical structural validity – *Are the example problems used in modeling the method appropriate choices?*

- In Section 4.2, it is presented the text mining framework and related functionalities: data cleaning, data management, text analysis and visualization results. The text mining framework integrates the methods to help translate the text contents of learning statements into the visualization results.
- In Section 4.3, there are discussed the challenging aspects of the data cleaning methods and argue that the aspects are appropriate to test Hypothesis 1 - *A function for users to configure extraction rules can support users to deal with the large amounts of learning statements data.* Data cleaning methods are used to transform the unstructured text data into structured and remove the insignificant parts of the text contents.
- In Section 4.4, it is discussed the challenging aspects of the text mining methods and argue

that the aspects are appropriate to test Hypothesis 2 - *Integrating multiple text mining algorithms in a program can facilitate comprehensive mining of the learning statements from different perspectives.* Text mining methods are used to compute and analyze the data for understanding the text contents from different perspectives.

- Besides, existed software is discussed to visualize the formatted dataset, and more suitable visualization methods are used to deal with our triple-structured learning statements in Section 4.5. There are the challenging aspects in the using visualization methods and I argue that the aspects are appropriate for us to test Hypothesis 3 - *Using visualization tools such as word frequency histogram, text network, and text similarity rate can help instructors gaining new knowledge or insights from the learning statements*.

CHAPTER 5 PROGRAM AND INTERFACES



In Chapter 4, the text mining framework and related functions are discussed to realize the hypothesis which are related to the research gaps of the thesis. In this chapter, the text mining program is designed with the functions of the text mining framework. The workflow of the text mining program is followed by the text mining framework from users' perspective. The execution steps in the workflow of the text mining program are illustrated in Section 5.2. By checking the testing textual data, the text mining program is verified its accuracy in Section 5.3. The interfaces of the text mining program are presented in Section 5.4. With overview of the text mining program in Chapter 5, the empirical structural validity is extending to be validated through developing the execution workflow of the program. In Appendix.B, the user menu of the text mining program can help users, such as instructors and students generate different visualization results through selected assignment documents by themselves. In Appendix.C, the handbook of the text mining program is instructing people to develop the program in their local computers.

5.1 OVERVIEW OF THE TEXT MINING PROGRAM

The text mining program is developed from the text mining framework. There are four key

functions in the text mining framework: data cleaning, data management, text analysis, and visualization results. The expectation of the text mining framework and program is to generate meaningful visualization graphs from the original textual data. So the input data of the text mining program is the original textual documents, and the outcome results are different insightful graphs. With the implemented processing from the input documents to outcome visualization results, there is transitional data which needs to be stored in the defined relational database of the text mining program, named cleaned data. So the text mining program is divided into two parts: 1) data cleaning and management and 2) analysis and visualization. In the first part, the input textual documents are handled with configure rules and transformed into cleaned data to save in the structured database. And in the second part, the cleaned data can be selected to compute with different text mining algorithms and generated into the corresponding graphs. Details of the execution workflow will be described in next section, and execution steps are presented with the translation processing as follows.

5.2 THE EXECUTION STEPS OF THE TEXT MINING PROGRAM

5.2.1 The Execution workflow of the Program

In this section, it is discussed the execution workflow of these functionalities and interfaces, as shown in Figure 5.1. The execution workflow facilitates verifying the theoretical validity of the text mining framework.

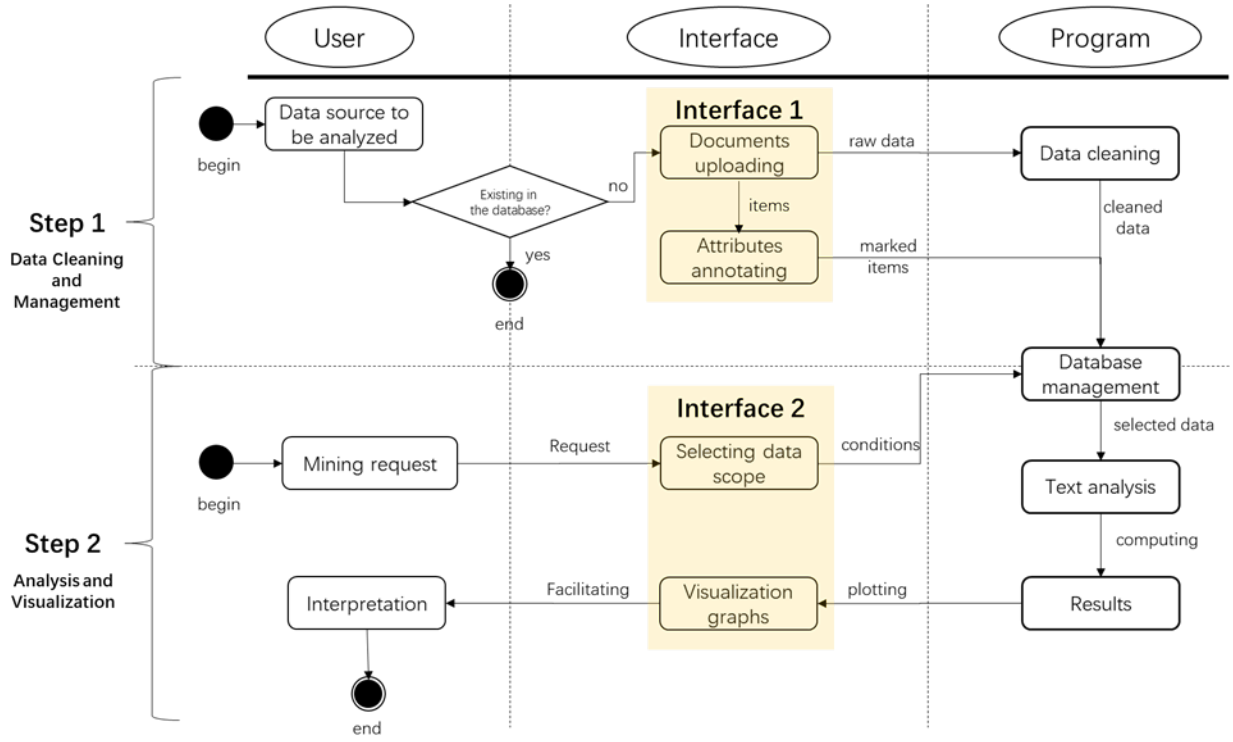


Figure 5.1 Execution Workflow of the Text Mining Program

The execution workflow comprises of two parts: Part 1 is data cleaning and management, as shown in the upper row of Figure 5.1; Part 2 is analysis and visualization, as shown in the lower row of Figure 5.1. There are three objects involved in the workflow: user, interface, and program. In Part 1, a user begins with data source to be uploaded. If the data source exists in the database, the execution of Part 1 ends, otherwise the user uploads the original textual documents to the program in Interface 1, and annotate these uploaded documents using related attributes. By executing the data cleaning functionality, the text mining program transform the raw data of the uploaded documents into clean data, and then save the clean data to the database with related attributes. In Part 2, a user begins with a mining request. Based on the request, the user select the data scope in Interface 2. The selected data scope then generates the corresponding searching conditions in the database, with which the program can obtain the matched data and feed this data to text mining algorithms for computing. The computing results are sent back to Interface 2 for plotting. The plotted visualization graphs are used to facilitate the user gaining insights about the text contents.

The four functionalities – data cleaning, data management, text analysis, and results visualization are executed following the logic defined in Figure 5.1. The execution workflow is a closed loop

where a user begins with the raw textual data and ends with the graphical text mining results and the related knowledge, which verifies the theoretical validity of the text mining framework.

5.2.2 The Execution steps and Data Translation between Steps

The first execution step is data cleaning and management with the input original documents. In the execution step of data cleaning and management, the configure rules are automatically matching to the attributes of documents. The processed textual contents are extracted from these documents with the indicated configure rules, which are natural language needs to be cleaned. The data cleaning methods are used to clean the textual contents to extract meaningful key phrases. When the cleaned data is generated in the text mining program, the outcome data of the first execution step would be stored into the relational database with the attached attributes. Data translation happened in the step of data cleaning and management is from the textual documents to cleaned key words.

The second execution step is analysis and visualization with the alternative conditions. The alternative conditions are used to select the demanded data from the database with desired expectation for the data. The text mining algorithms and visualization methods are defined and selected with users' desired expectation to compute and visualize the demanded data. Data translation happened in the step of analysis and visualization is from the selected data to visualization results.

5.3 THE VERIFICATION OF THE HYPOTHESIS IN THE PROGRAM

In order to verify that the text mining framework can produce correct results, the webpage text (the introduction of text mining techniques) from Wikipedia (https://en.wikipedia.org/wiki/Text_mining) is tested as a sample input. Table 5.1 is the comparison between the expected word (top five of the most frequent words) counts and test results generated by the text mining program. It is observed from the table that the rest results meet the expectation very well. This observation is further confirmed by Figure 5.1, where the histogram and word cloud of the sample text are shown. The top five of the most frequent words found in the histogram and word cloud, namely, "text", "mining", "analysis", "use", and "data", are consistent

with what are shown in Table 5.1. Therefore, it is safely said that the text mining program can produce correct results.

Table 5.1 Comparison Between Expectations and the Test Results

Most Frequent Words (top 5)	Expected Counts	Test Results
"text"	95	95
"mining"	65	65
"analysis"	34	34
"use"	28	28
"data"	25	25

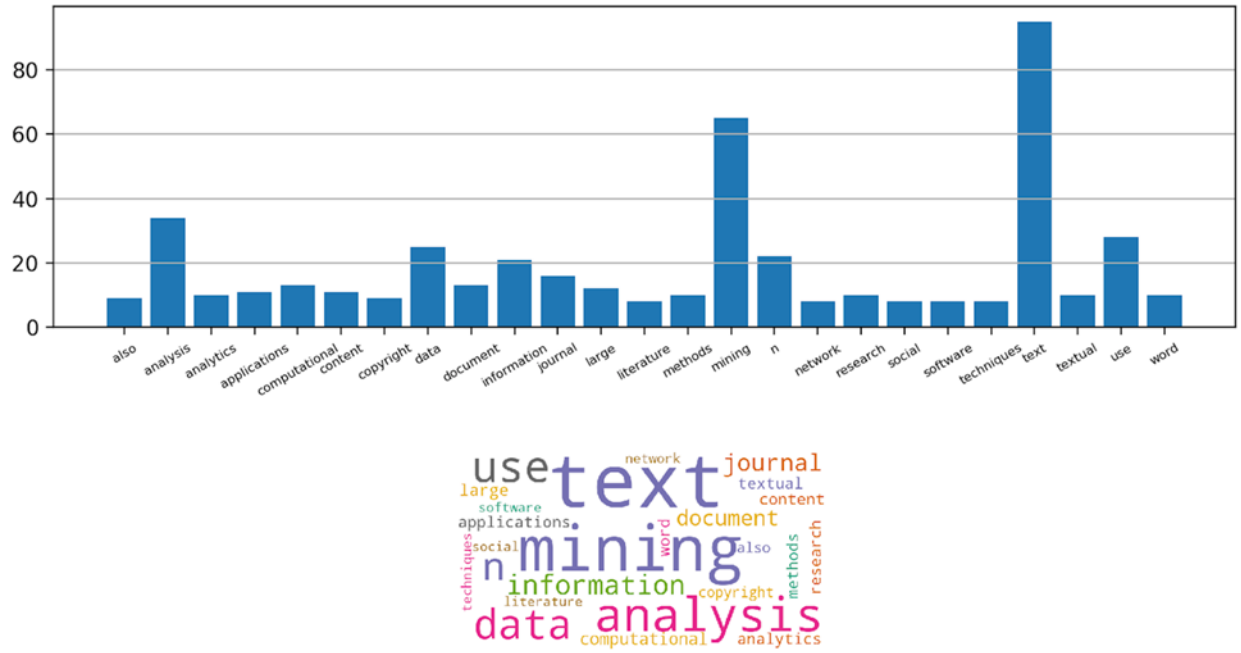


Figure 5.2 The Visualization Results with Sample Data

5.4 THE RELATED INTERFACES OF THE PROGRAM

In the text mining program, there are two user interfaces, namely, the text pre-processing interface and the text analysis interface, as shown in Figures 5.3 and 5.4 respectively. The text pre-processing interface is used for users to upload original documents and attach attributes to the documents to be uploaded. In the text pre-processing interface, users click the "upload" button, select the document that they want to upload, fill in the attribute fields (i.e., Semester, Section, Assignment) to attach associated attributes to the text documents, and click the "submit" button to finish the uploading. In the text analysis interface, users fill in the condition fields (i.e., Semester,

Section, Assignment, POED, Grade) to set up the scope to fetch learning statements from the database, and click the "Text Mining" button to see the plots of the text mining results.

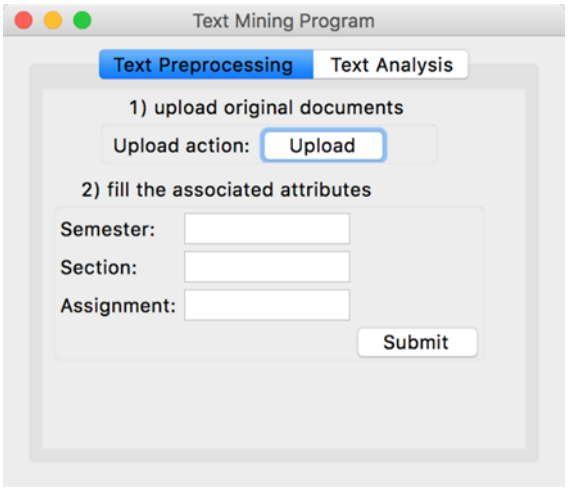


Figure 5.3 The Text Preprocessing Interface

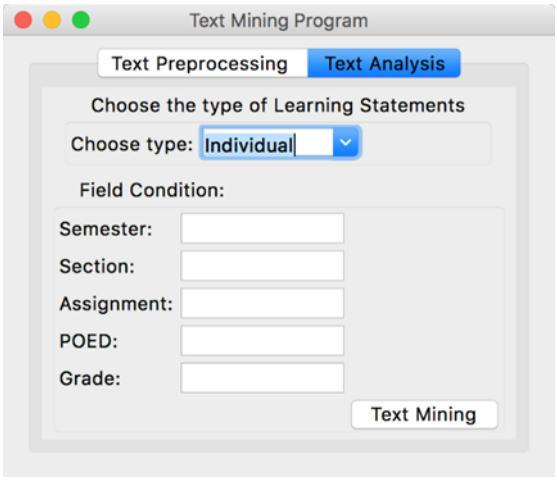


Figure 5.4 The Text Mining Interface

5.5 ON VERIFICATION AND VALIDATION – EMPIRICAL STRUCTURAL VALIDITY (ESV)

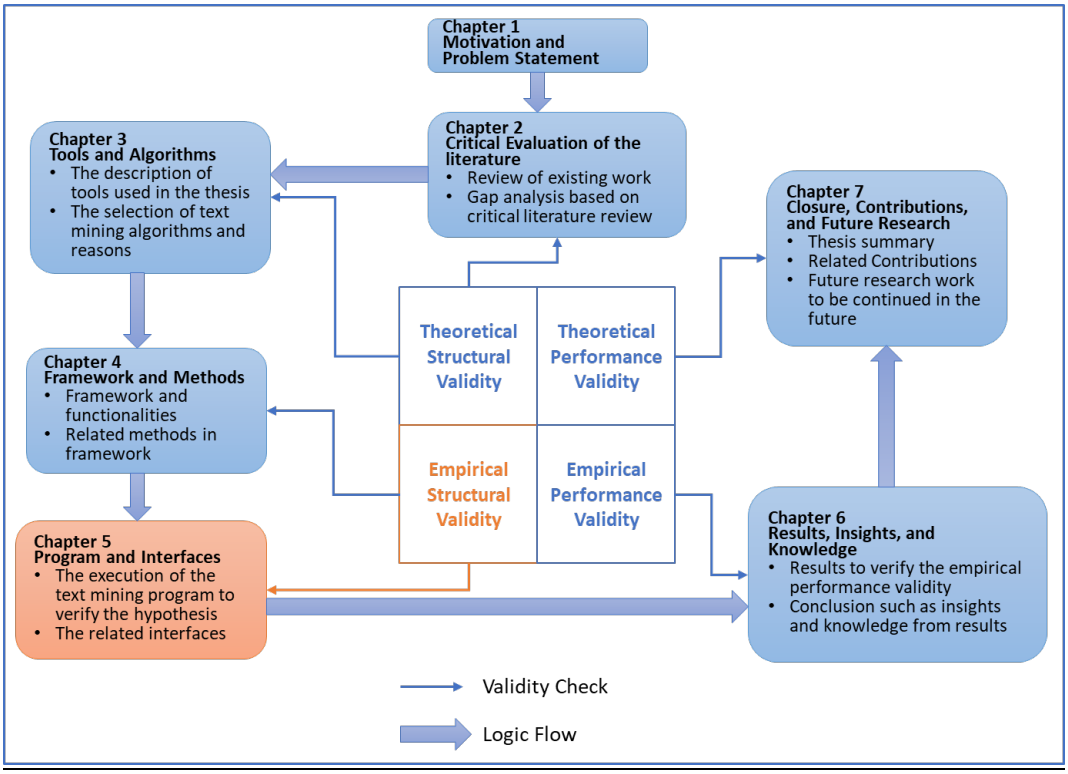


Figure 5.5 Validation Square of Chapter 5

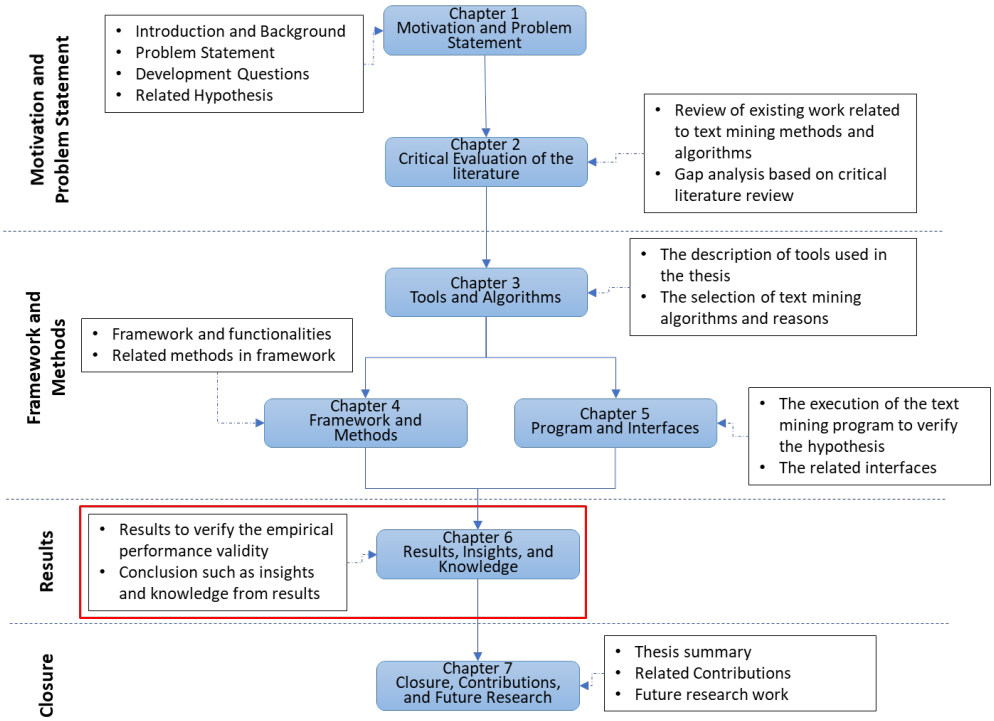
In this chapter, it is presented the text mining program for implementing the corresponding framework. The text mining program and the implemented workflow help to verify the question in Empirical structural validity – *Are the example problems used in modeling the method appropriate choices?*

- In Section 5.2, the execution workflow of the text mining program present the processing flow of the data in the program and related interfaces. Two steps of the text mining program which are 1) data cleaning and management and 2) analysis and visualization are used to transform the original textual data into visualized graphs. These visualization graphs are implemented by the text mining program, which can be used to verify the empirical structural validity of the thesis.
- In Section 5.3, the text mining program is using test data to verify the consistent expected results, which makes sure the accuracy of the program meets the expectation when

developing it.

- In Section 5.4, the related interfaces are presented as designed in the text mining framework. Two key interfaces are related to the corresponding functions which can be used to deal with the data and generate the visualization results.

CHAPTER 6 RESULTS, INSIGHTS AND KNOWLEDGE



In Chapter 5, the text mining program is presented with related workflow, execution steps, and interfaces. In this chapter, there are the visualization results generated from different text mining algorithms and visualization methods, including word cloud, text network. Based on these results, some recommendations and comments are related to introduce from different perspectives in Section 6.1, 6.2 and 6.3. More statistic results and analysis are presented in Section 6.4. Through the visualization results generated from the text mining program, the key elements are identified for answering the development questions with empirical performance validity, which maps to Quadrant 3 of the Validation Square in Section 1.4.

6.1 THE STATISTIC ANALYSIS OF WORD FREQUENCY

In this section there are the word clouds and the bar charts based on the analysis of data collected in three offerings of the course, namely, Fall 2017, 2018 and 2019. The comments comes from these word clouds and can be used to help change the instructors plan for Fall 2020 to improve the course.

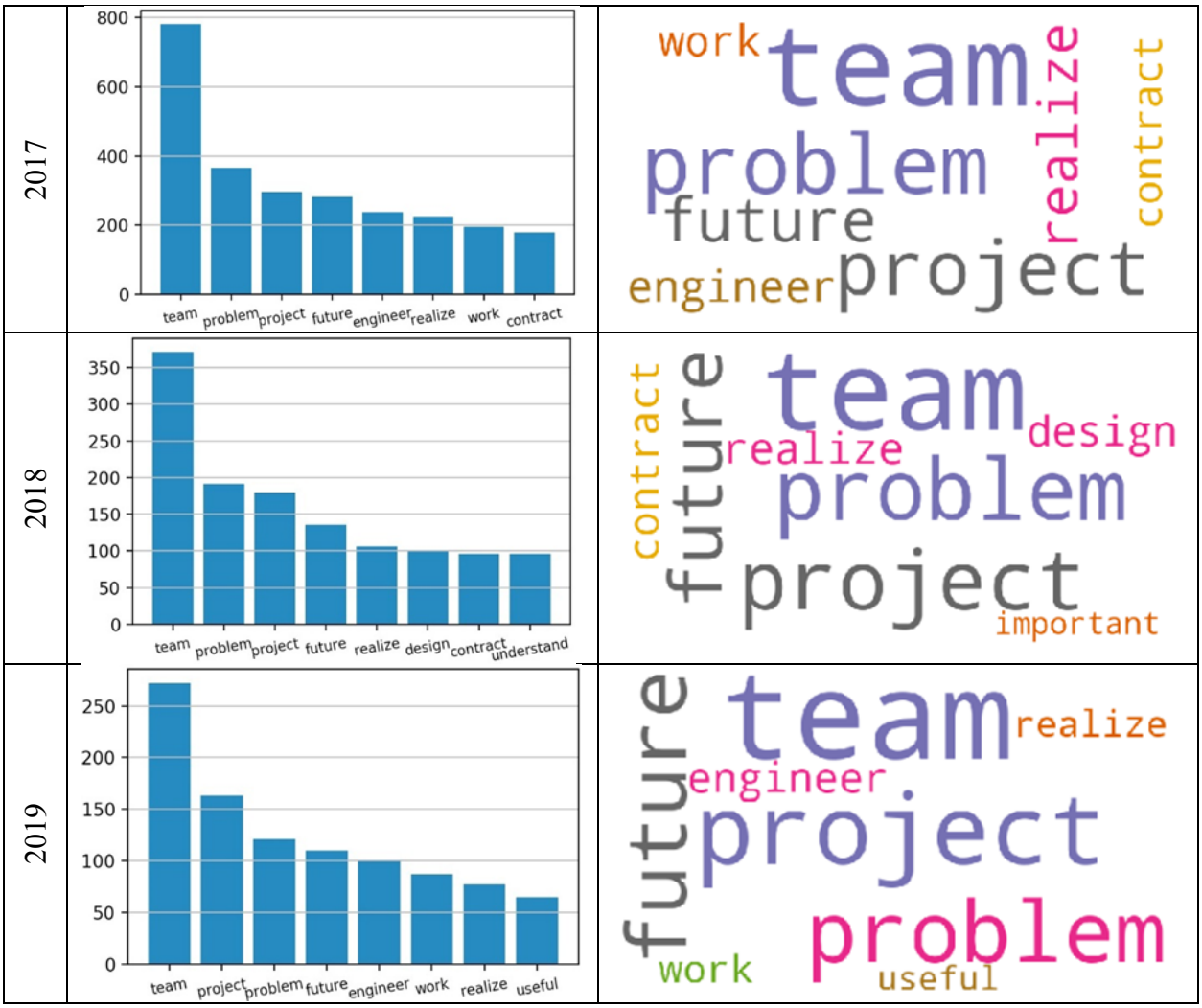


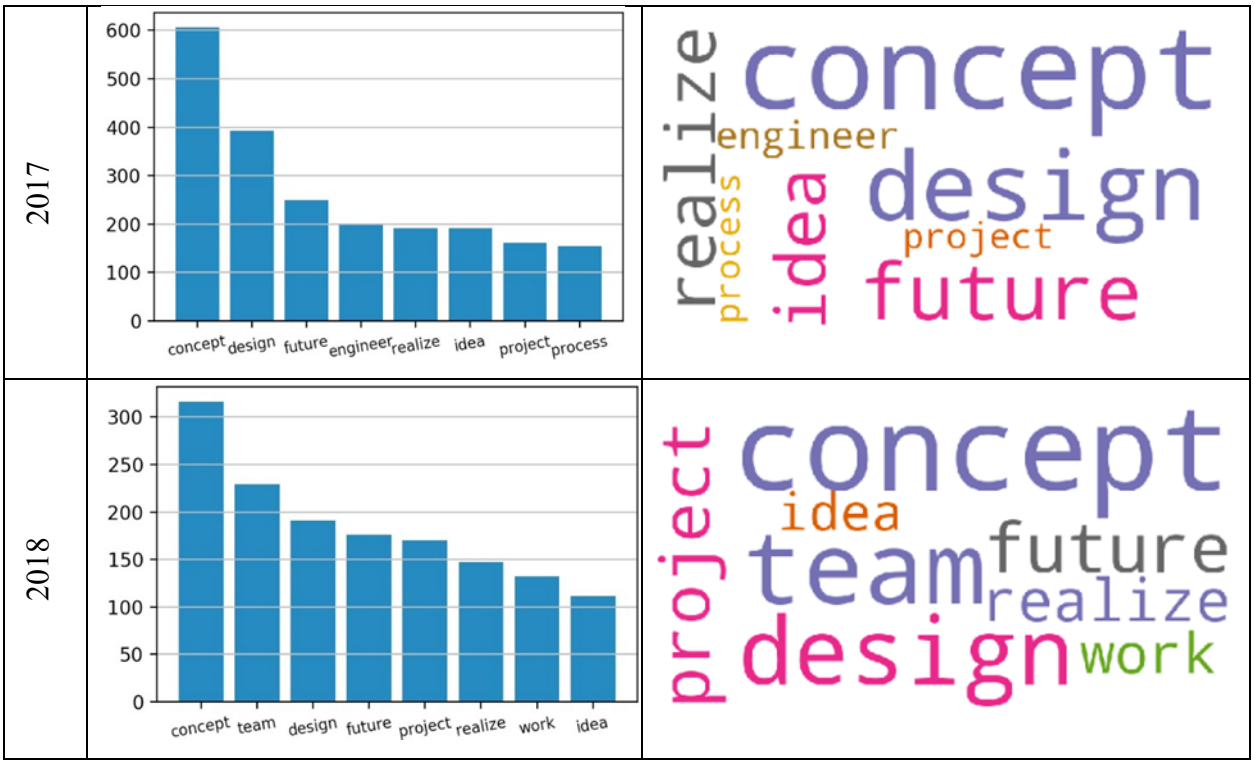
Figure 6.1 Mining results on Assignment 1 (For Given and Provide see Table 1.2)

The POEDs that are proposed for Assignment 1 are (see Figure 1.2):

1.a Forming a team
1.b Accepting and executing a team contract to stipulate ethical guidelines to decision making and problem resolution
1.c Understanding the problem and framing the problem statement
1.d Proposing a plan of action
5.b Articulating, using learning statements, the Principles of Engineering Design that you have internalized

Commentary: In Assignment 1, it is expected that keywords such "problem", "team", "contract", "requirement", "list", etc. should appear frequently the Junior Engineer's learning statements.

From the results, shown in Figure 6.1, “problem”, “team” are ranked within the top 8 most frequent words in all three years, which means that most of the Junior Engineers have internalized the associated concepts and this is reflected in their learning statements. Another observation is that the word “contract” appears as top-8 in 2017 and 2018, but does not appear in the same rank 2019, which means that the concept of “contract” was not attached too much importance in 2019. Similar issue is found in terms of the words of “requirement” and “list”. These two words do not appear in the top-8 rank of all the three years. Based on these observations the instructors in 2020 will fix the associated lectures so that Junior Engineers pay more attention to the twin concepts of “contract” and “requirement list”.



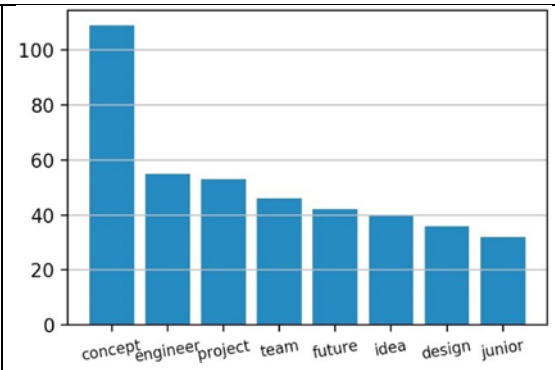
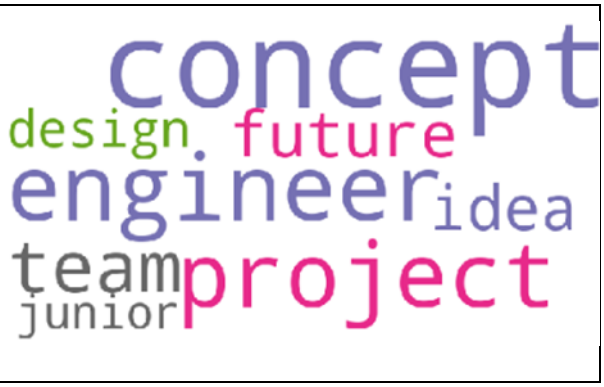
2019		

Figure 6.2 Mining results on Assignment 2 (For Given and Provide see Table 1.2)

The POEDs that are proposed for Assignment 2 are (see Figure 1.2):

1.d Proposing a plan of action
2.a Ideating and generating concepts
2.b Developing concepts to ensure functional feasibility, ensure realizability (technical feasibility)
2.c Evaluating the concepts (functional feasibility, technical feasibility) and identifying that system concept which is most likely to succeed
5.b Articulating, using learning statements, the Principles of Engineering Design that you have internalized

Commentary: In the past three years course instructors emphasized function structure and concept generation (the teams are required to generate 6 distinct concepts). From the results in Assignment 2, the key word Concept shows up in all three years. In Fall 2019 instructors emphasized course goal to provide an opportunity for students as Junior Engineers to hit the road running. And the word "Junior" shows up in the word cloud for 2019. It is expected that keywords such as "concept", "generate", "function" etc. should appear frequently in Assignment 2. From the word clouds in Figure 6.2, the word "concept" ranks at the top of the most frequent words in all three years, which means that it was internalized, as expected, in Assignment 2. the word "generate" doesn't appear in the top-8 most frequent words list in 2017, 2018, and 2019. But its synonym – "idea" (which is the root of "ideating") appears in the word cloud and the bar chart, which means that students have internalized the process of ideating and generating concepts. The word "function" does not appear in the word clouds and bar charts of Figure 6.2, which means that

"function" was not frequently mentioned in learning statements from 2017 to 2019. Therefore, the instructors of AME4163 will modify the lectures to place more importance on the POEDs associated with functional feasibility and realizability. In Fall 2020 instructors should emphasize the importance of the relationship between the Requirements List (Assignment 1) and the Function Structure (Assignment 3).

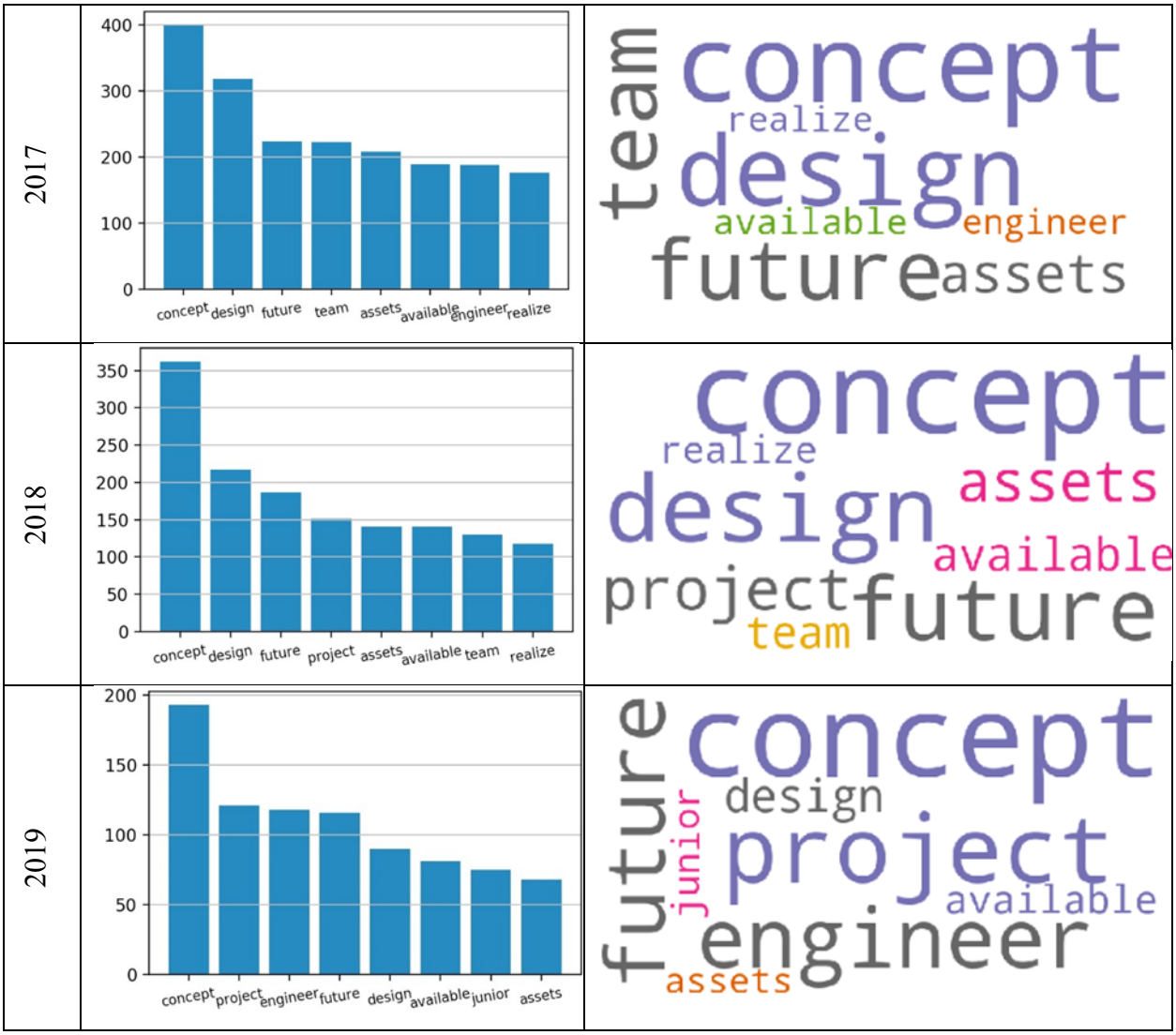
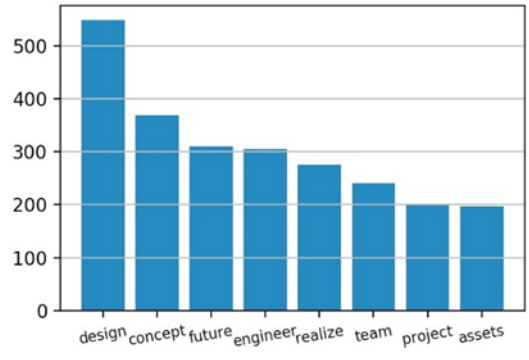
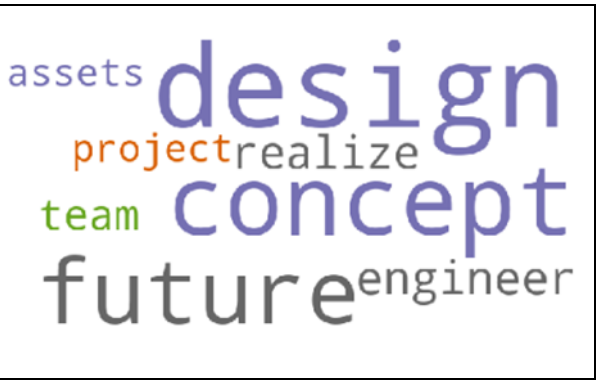


Figure 6.3 Mining results on Assignment 3 (For Given and Provide see Table 1.2)

The POEDs that are proposed for Assignment 3 are (see Figure 1.2):

1.d Proposing a plan of action 3.a Refining / modifying the most likely to succeed concept through technical analysis, experimentation and thought exercises 3.b Stipulating available assets 5.b Articulating, using learning statements, the Principles of Engineering Design that you have internalized

Commentary: In Assignment 3, students are expected to mention keywords such as "concept" and "assets" in their learning statements. It is observed in Figure 6.3 that these words appear in the word clouds and the bar charts for all the three years, which means that students have well internalized the target POEDs in Assignment 3. Therefore, it is safe to say that the lectures designated for the target POEDs produced good results in students' learning in 2017, 2018, and 2019. In Assignment 3 students down-select, taking into account functional and technical feasibility, from 6 concepts (generated in Assignment 2) to 2. Foundational to the down-select procedure is the creation of an available assets list and buildability/realizability. It is reassuring to see that the phrase "available assets" appears in all three word clouds. Realizability appears in the first two years but does not appear in the word cloud for 2019. This needs to be adjusted for in Fall 2020.

2017		

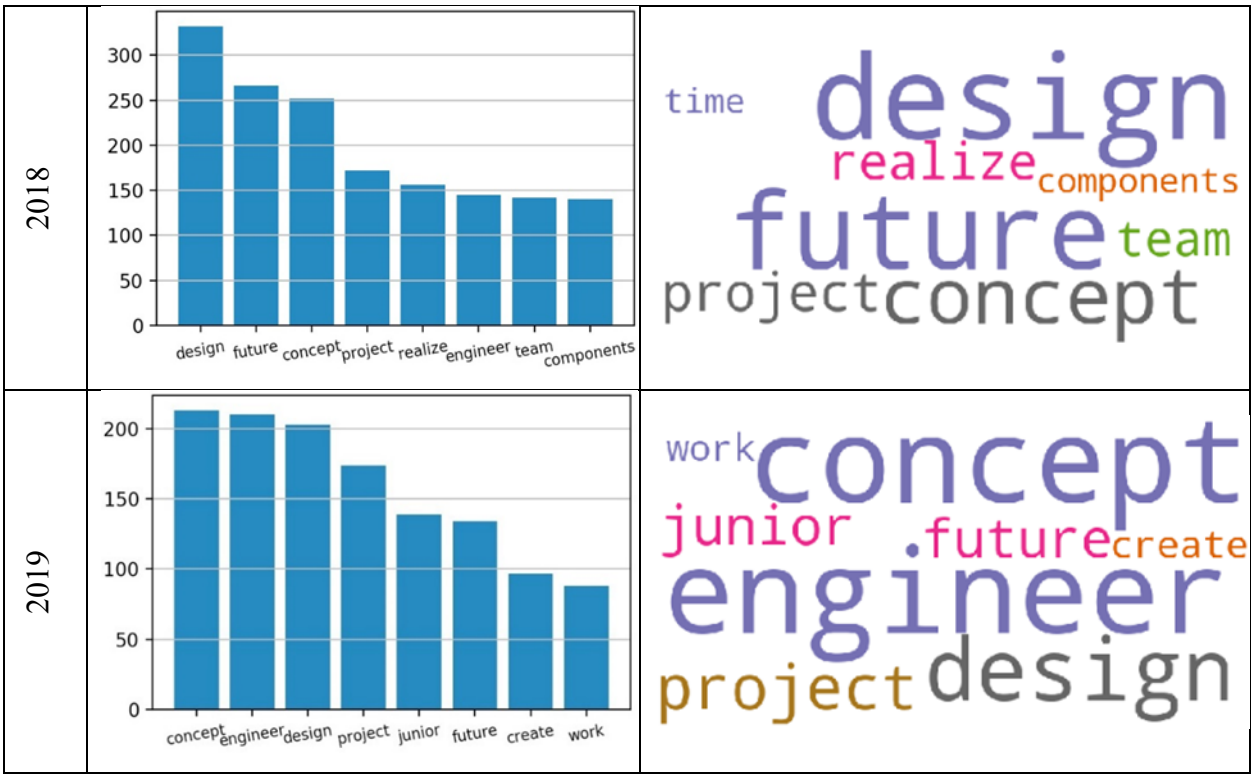


Figure 6.4 Mining results on Assignment 4 (For Given and Provide see Table 1.2)

The POEDs that are proposed for Assignment 4 are (see Figure 1.2):

1.d Proposing a plan of action
4.a Creating a bill of materials as built, including an understanding of the limitations and capabilities of the chosen components
4.b. Ensuring that the design as built meets target performance requirements
4.c Performing a critical analysis after device prototyping of causes of success and failure
5.b Articulating, using learning statements, the Principles of Engineering Design that you have internalized

Commentary: It is expected in Assignment 4 that keywords such as "concept" and "assets" should also frequently mentioned in the learning statements. It is observed from Figure 6.4 that "concept" appears in the word clouds and bar charts of all the three years, "asset" only appears in the visualization results for 2017 and disappears in both 2018 and 2019. In 2017 and 2018 the phrase 'Junior Engineers' were contemplating their Future. In 2019 the word Junior comes to the fore. Regrettably, the word Buildability / Realizability did not show up in any of the word

clouds. Instructors should fix this in Fall 2020.

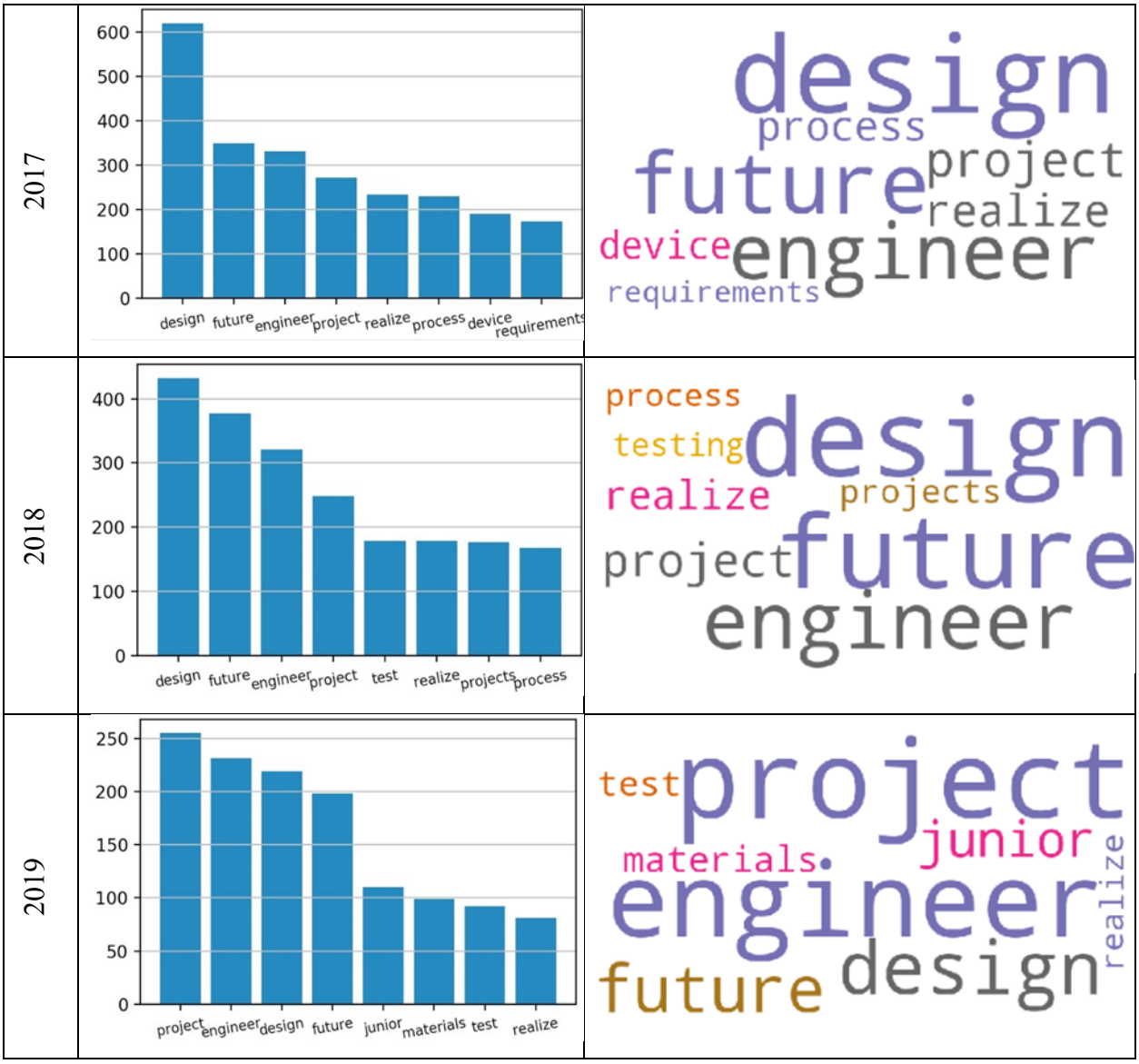


Figure 6.5 Mining results on Assignment 5 (For Given and Provide see Table 1.2)

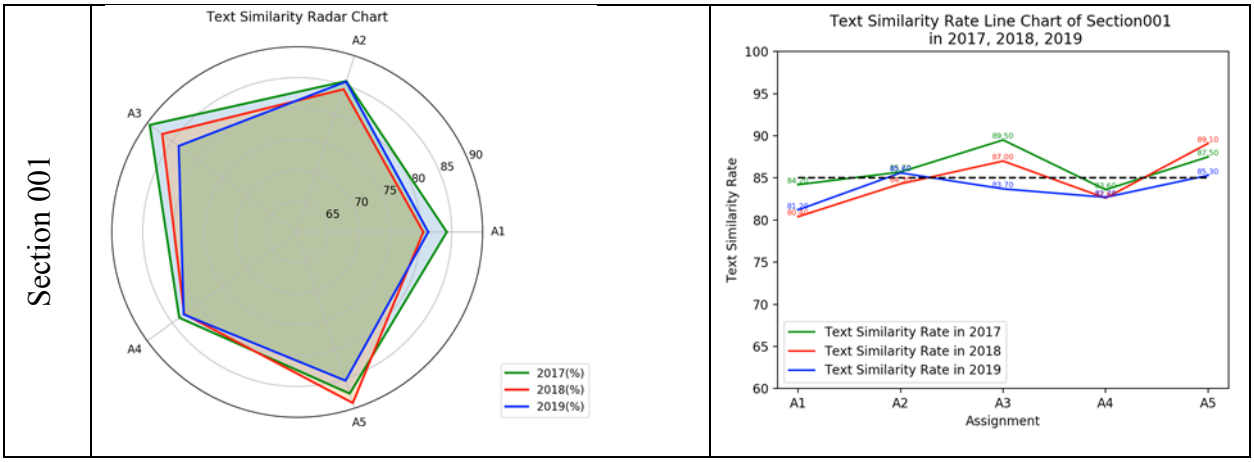
For Assignment 5 only one POED, namely, 5c Identifying new POED and carrying that knowledge into future projects and experiences is targeted; see Figure 1.2. In Assignment 5, it is expected that keywords such "design", "project", "success", "failure", "engineer", and "future" should be mentioned frequently in the learning statements. In Figure 6.5, the words "design", "project", "engineer", and "future" appear in the word clouds and bar charts of 2017, 2018, and 2019, which means that students have internalized the associated target POEDs in Assignment 5. However, both "success" and "failure" are not found in the visualization results, which means that very few

students (if not none) analyzed what went right, what went wrong and how to fix in their learning statements. The instructors need to rethink how to structure this assignment and perhaps include a lecture emphasizing the importance of learning how to create new POEDs.

The graphs of histogram show the order of key words in students' learning statement, which can be used to compare students' focusing in different years. For additional, the graphs of word cloud show the results of histogram in a visualized way. The most important word of students' learning statements in assignments shows most visible in the graph of word cloud. By comparing the visualization results in three years, students' focusing are obviously presented for instructors to gain insights from the comparison.

6.2 THE STATISTIC ANALYSIS OF TEXT SIMILARITY

At OU, there are typically over 150 students enrolled in AME4163 every year. In order to ensure that each student can get sufficient attention and support in the course, AME4163 is divided into two sections, Sections 001 and 002 (students can choose either one section to attend), taught by two different instructors. In these two sections, the lecture content, assignments, and POEDs are all the same. In Figure 6.6, the analysis results of students' learning (indicated by the similarity between their learning statements and the target POEDs) are shown as two sections.



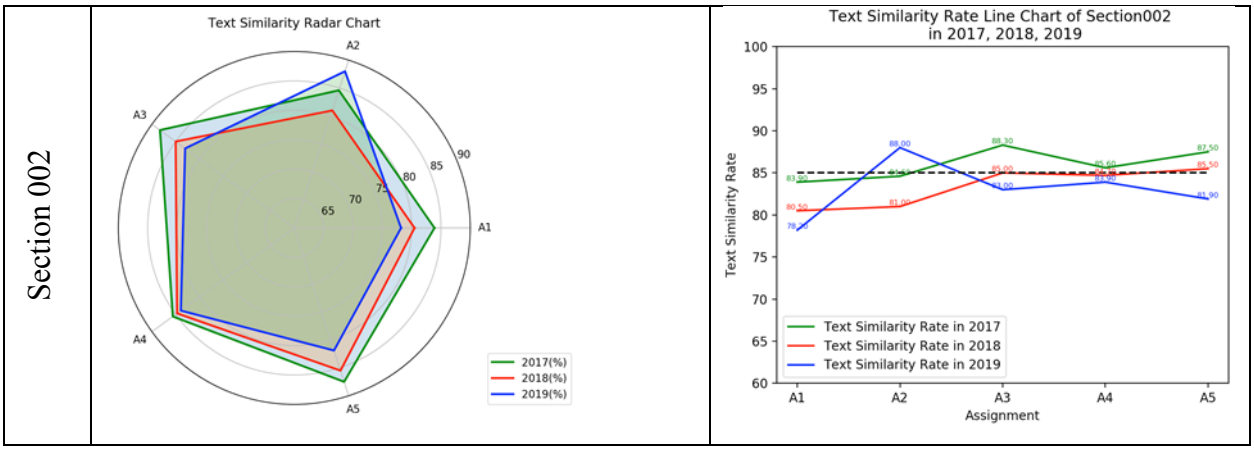


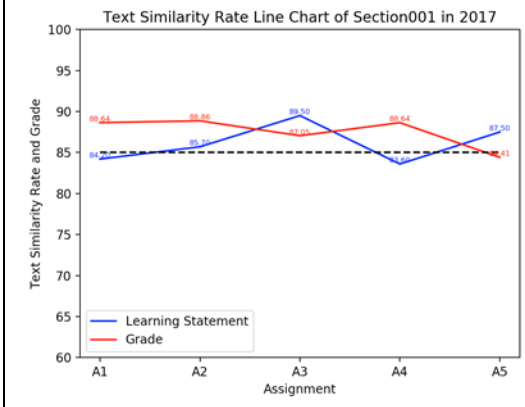
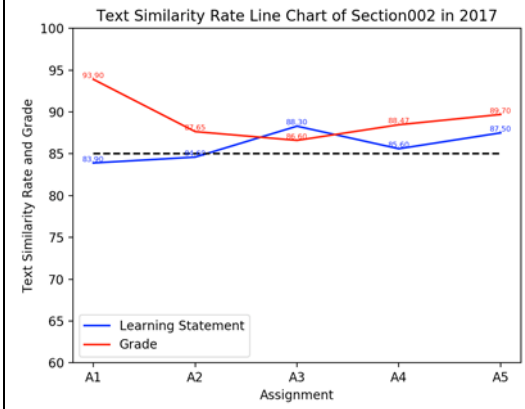
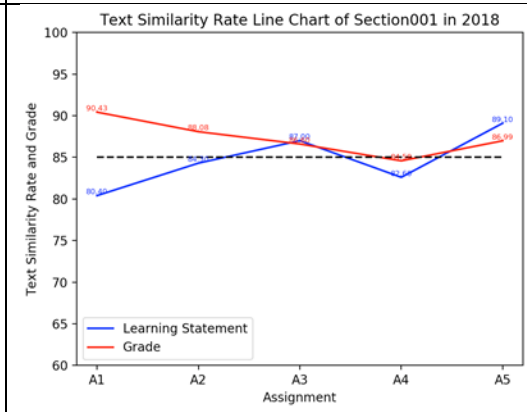
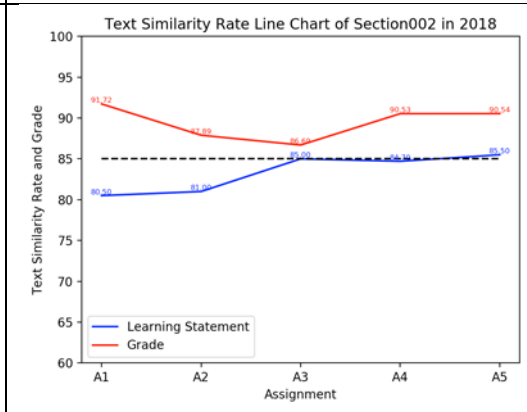
Figure 6.6 Students' Learning Results in Two Different Sections

In the results of Section 001, a consistent pattern is shown from 2017 to 2019. The pattern is that the similarity rate is relatively high in Assignments 3 and 5 (over 85%), and is relatively low in Assignments 1 and 4 (under 85%). One of the possible reasons for low similarity rate in Assignment 1 is that students are not familiar with the requirements of the course at the beginning of the semester, so their learning statements do not well match the target POEDs well (this is normal). In Assignment 5, the similarity rate increases to a higher level, and this is because students are asked to reflect what they have done in the previous four assignments and articulate the lessons learned and most of the students are quite familiar with POEDs at that stage. However, the instructor needs to pay particular attention to Assignment 4 because there is an "abnormal" low similarity rate. Assignment 4 is about prototyping, testing and post-mortem analysis, and students are expected to reflect on what went right, what went wrong and articulate changes (with justification) they would make moving forward. In the light of low similarity rate observed in Assignment 4, the instructor is recommended to fix the lecture and help students better internalize the associated POEDs in 2020.

In Section 002, there is an inconsistent (or mismatched) pattern from 2017 to 2019. The overall similarity rates in Assignments 1 through 5 are relatively lower than those in Section 001. This may be due to a different teaching style used by the instructor of Section 002. However, an exceptionally high similarity rate (88%) of Assignment 2 is shown in 2019, which is even higher than that is in Section 001. This may be due to some adjustment in lectures pertaining to Assignment 2 took place in 2019. The recommendation here is that two instructors communicate and identify the differences in their teaching styles, particularly the difference in lectures related

to Assignment 2, so as to find the factors that lead to high similarity rate and leverage them for teaching in 2020. In addition, a low similarity rate is observed in Assignment 4 of both sections, therefore I recommend that the two instructors also need to work together to collectively address the same bottleneck.

Learning statements reflect what students have learned and the value they gained, while their performances reflect how good is the outcome when they apply what they learned in accomplishing the assignments (i.e., their doing). From Figure 6.7, the correlations between students' learning (indicated by similarity rates) and the grades they get are shown clearly.

	Section 001	Section 002
2017		
2018		

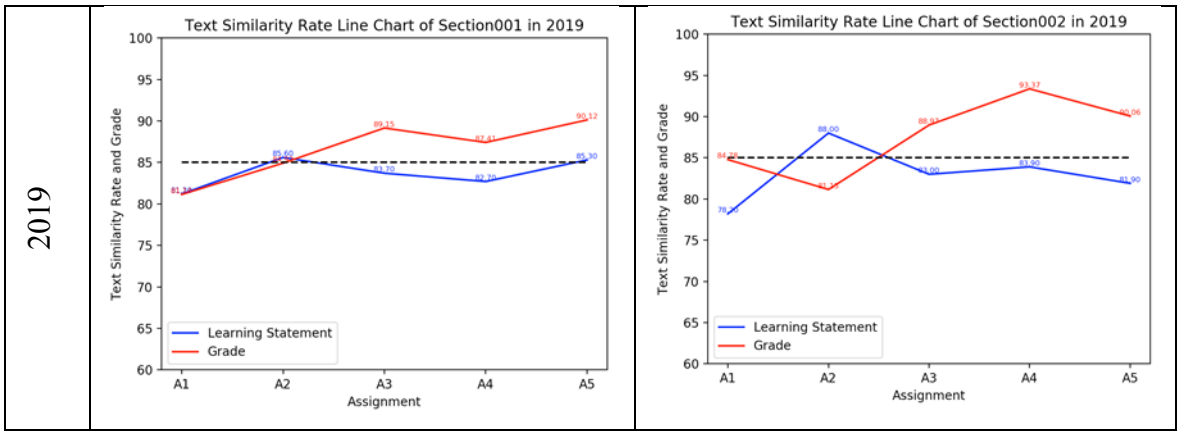


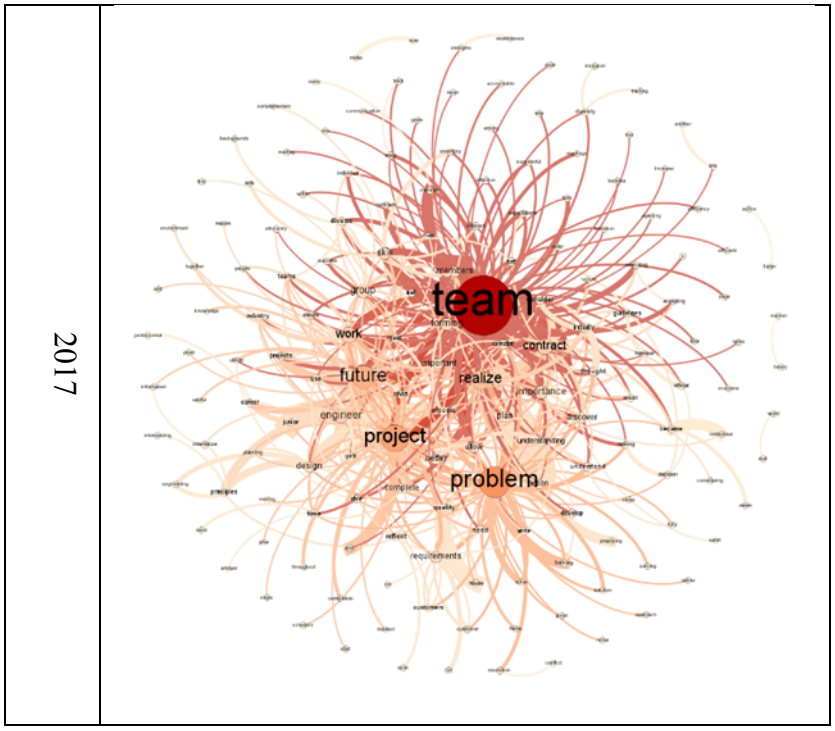
Figure 6.7 Correlations Between Students' Learning and Grades

Figure 6.7 is shown the comparison of the learning statements similarity rates and the grades in both sections from 2017 to 2019. Typically, if students' learning statements similarity rate increases from one assignment to another (which means that they have better internalized the target POEDs), then it is expected to see the same increasing trend in their grades (which means that students have used what they learn to perform better in the project), and vice versa. In the results of 2017, there are conflicts in Assignments 3 and 4 of Section 001. There is an increase of learning statements similarity rate from Assignment 2 to Assignment 3, however, the trend of grade is opposite. It indicates that students' doing (i.e., performance) does not match what they claimed they have learned, and it is important for the instructor to help them improve their doing in Assignment 3. From Assignment 3 to Assignment 4, the similarity rate decreases but the grade increases, which means that students' doing is better that their reflection (i.e., learning) and the instructor should remind students to do better reflection after they accomplish the assignment. Same conflicts are observed in Section 002 in 2017. In 2018, the conflicts between students' learning and grades occur in Assignments 2 and 3. In 2019, the number of conflicts reduces to only one, namely, the conflict occur in Assignment 2 of Section 002 where student performance does not match what they claimed they have learned. Therefore, the recommendation for the instructor is to help students improve their doing in Assignment 2 for Fall 2020.

For identifying the relation between students' learning statement and their grades, the principles of engineering design are quantified as a base criterion to compute the similarity of learning statements in different assignments and different years. The text similarity results are presented in radar charts and linear charts for instructors to find out the mismatch part in the course.

6.3 THE STATISTIC ANALYSIS OF TEXT NETWORK

Figure 6.8 are shown the text networks of learning statement related to Assignment 1 in 2017, 2018 and 2019. In Assignment 1, instructors require students to focus on the target POED that are mentioned in Table 1.2. it is expected that students should pay attention to ‘problem statement’ and ‘team contract’. From the text networks, It is observed that in all three years, ‘team’ and ‘problem’ are the two biggest words which means they are frequently and independently mentioned in students’ learning statements, and ‘team contract’ is the closest word-pair (phrase) which means it is frequently reflected in students’ learning statements. At the meantime, the density of the text networks (including nodes and edges) is descending from 2017 to 2019. The density is measured by the numbers of nodes and edges in the text network. One of the reasons why the density is descending is that students’ attention is more and more concentrated on the targeted POED. Another reason is that the course booklet contents are changed in the course AME4163 in 2019. The key change is that students are required to summarize their take aways before writing a learning statement in 2019, which was suggested in 2018, but not required or suggested in 2017. Writing take aways helps students review the related POED in the assignments, which then results in the fact that they focus more on the POED when they write learning statement.



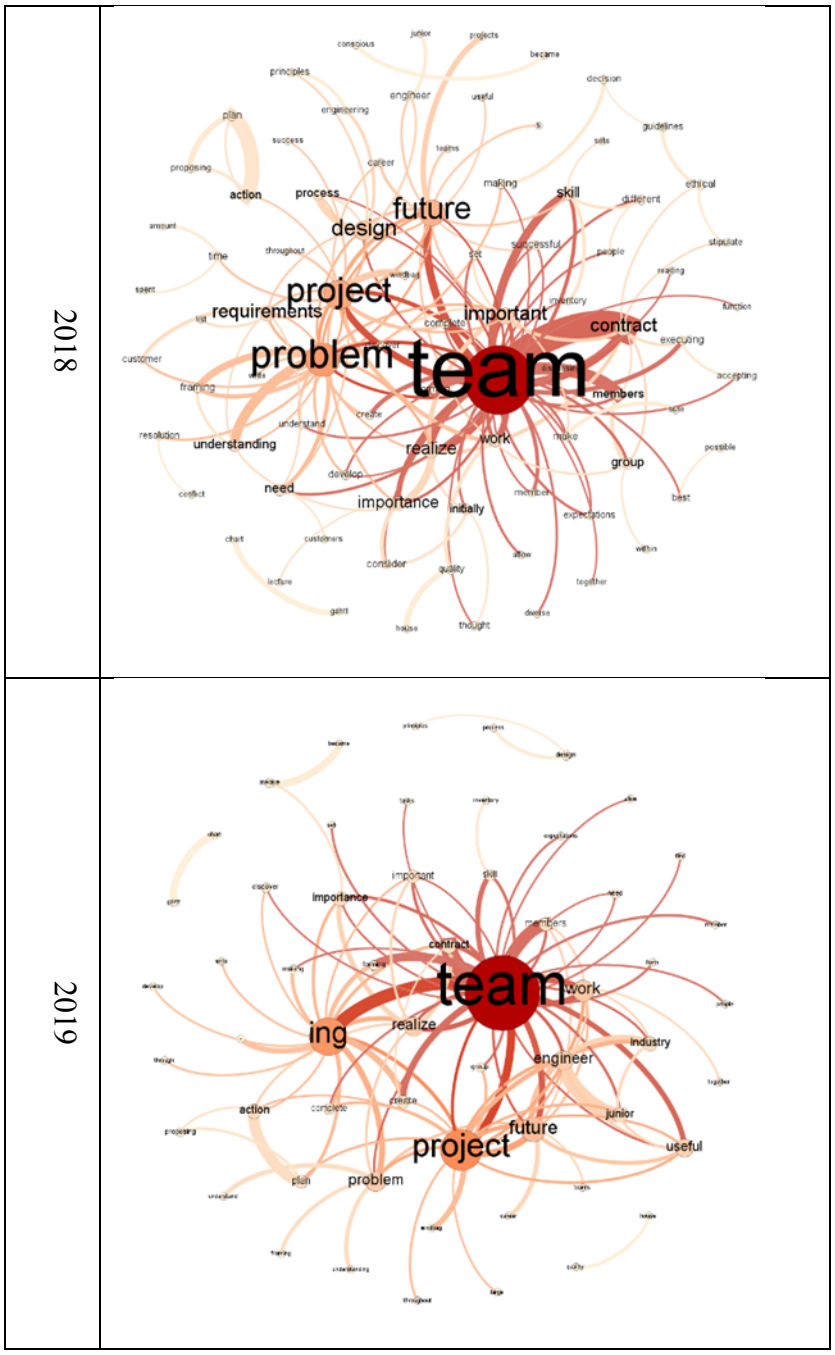


Figure 6.8 Text network results on Assignment 1

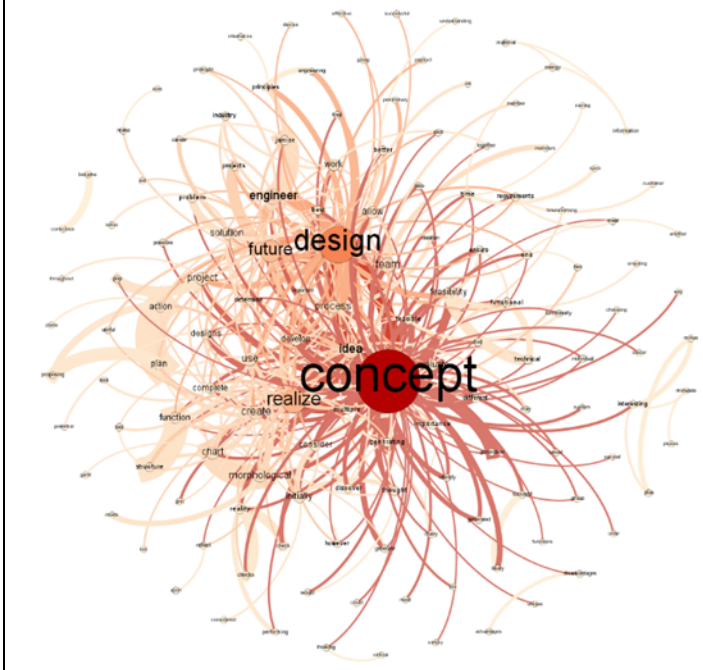
With the explanation of the text network in Assignment 1 to compare the graphs between 2017, 2018, and 2019, these conclusions can be summarized as:

1) In all graphs of text network in 2017, 2018, and 2019, the links of team – project and team – problem are shown evidently. For students, the most important tasks are team contract and

problem statement in Assignment 1.

2) The most closeness of words connection is team – contract in the graph of 2018. As instructors' expectation, students should pay attention to the team forming and team collaboration in their learning statements which has been reflected in the graphs of Text Network.

3) In the results, the graph in 2019 which is the most clearness than other two years shows that students' reflections are more and more focusing on the relation between POED and their works in 2019 with the help of take aways.

2017	

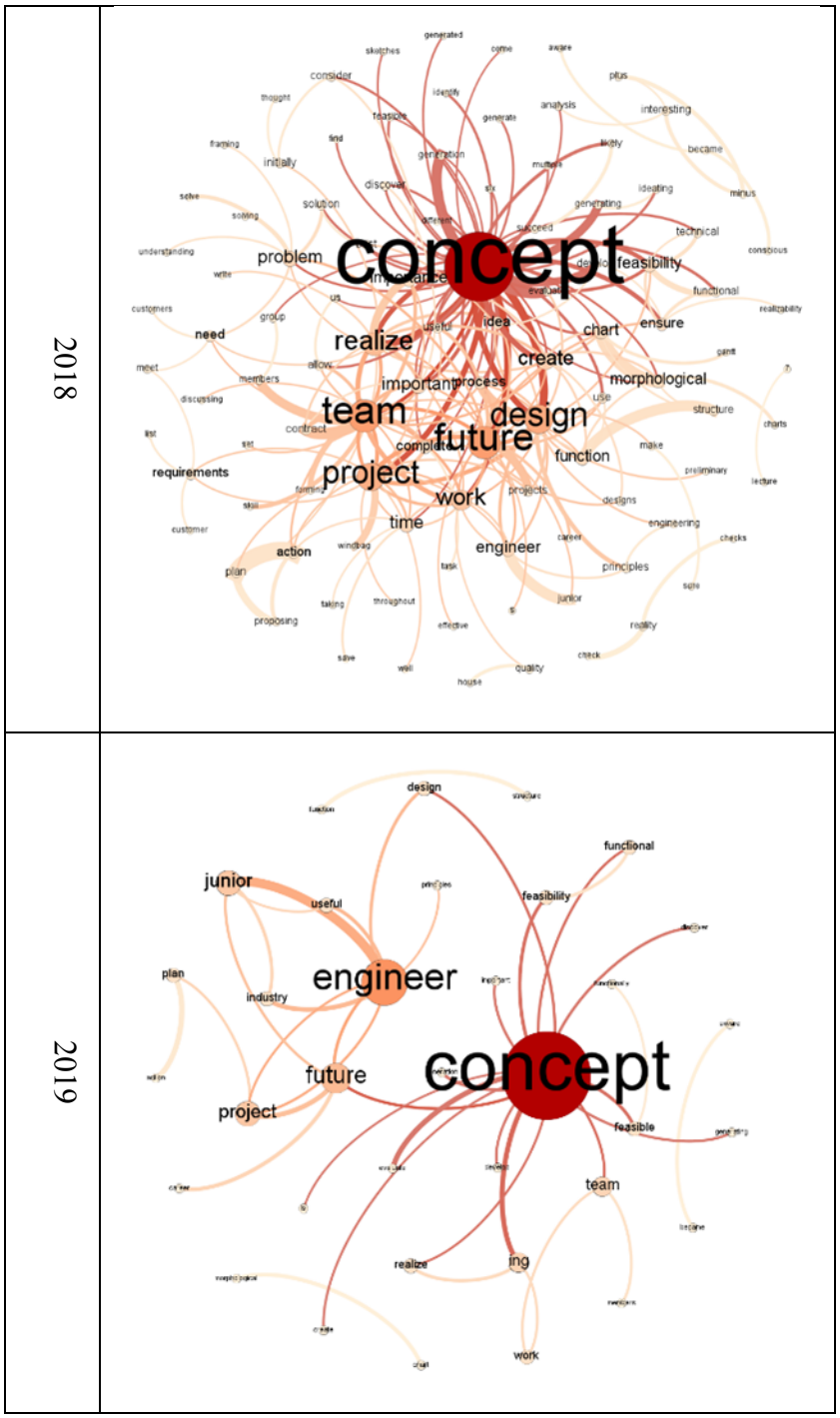


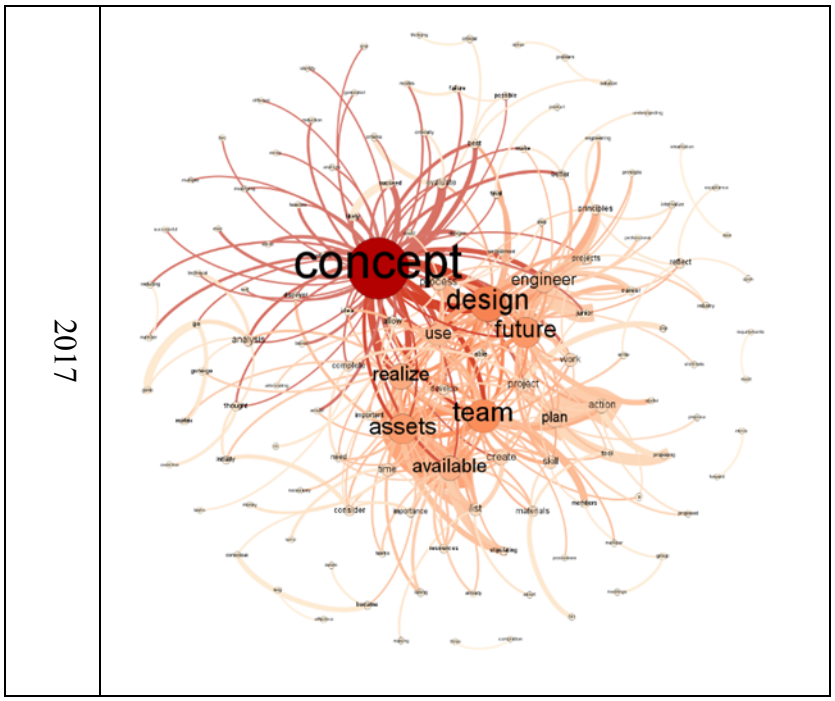
Figure 6.9 Text network results on Assignment 2

In Assignment 2, the text mining method of Text network is used to reveal the internalize value in students' learning statements by comparing the visualization results between 2017, 2018, and 2019:

1) In all graphs of text network in 2017, 2018, and 2019 , most students cares about the value of

concepts through their learning statements. Especially in 2017, the connection between concept and design from the graph of text network is easy to find out. At the same time, from the graph in 2018, there are many apparent words to connect the word of concept: team, project, future, design, which differs from the graph in 2017 and 2019.

2) In graph of 2019, students begin to reflect the value of the engineering design course into their future career as junior engineers. The network between the words of ‘junior’, ‘engineer’ and ‘future’ is shown clearly in the graph, which means students consider the value of concepts in their future career.



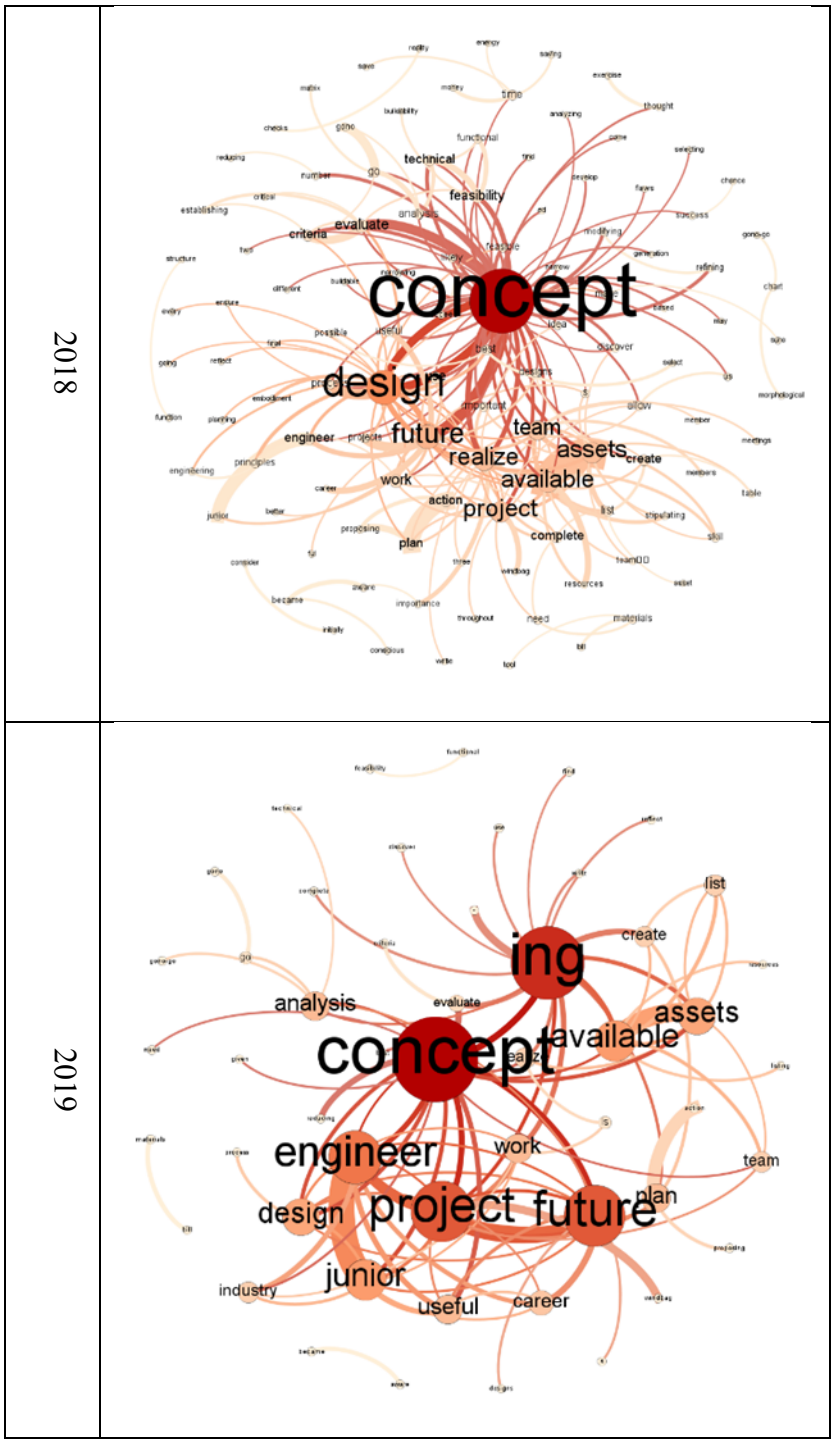
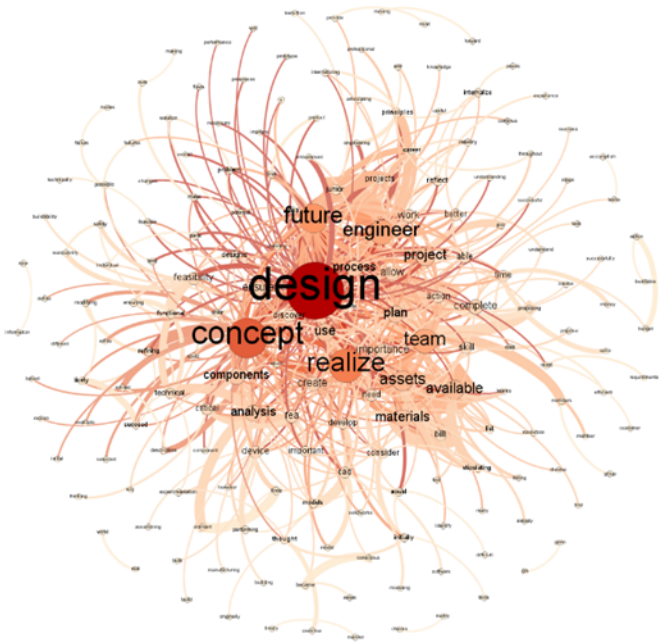


Figure 6.10 Text network results on Assignment 3

The visualization results from Assignment 3 are similar with the results from Assignment 2. The central word in all six graphs is concept, which is also the most important word in Assignment 2. Besides this finding, there are another conclusions from the comparison between 2017, 2018, and

2019:

1) From the graphs of text network in Assignment 3, there is a stable connection between the words of ‘available’ and ‘assets’, which students reflect their learning and values with POED 3b, Stipulating available assets.
2) In 2019, students become aware of future in the engineering career through the connection between future and engineer.

2017	

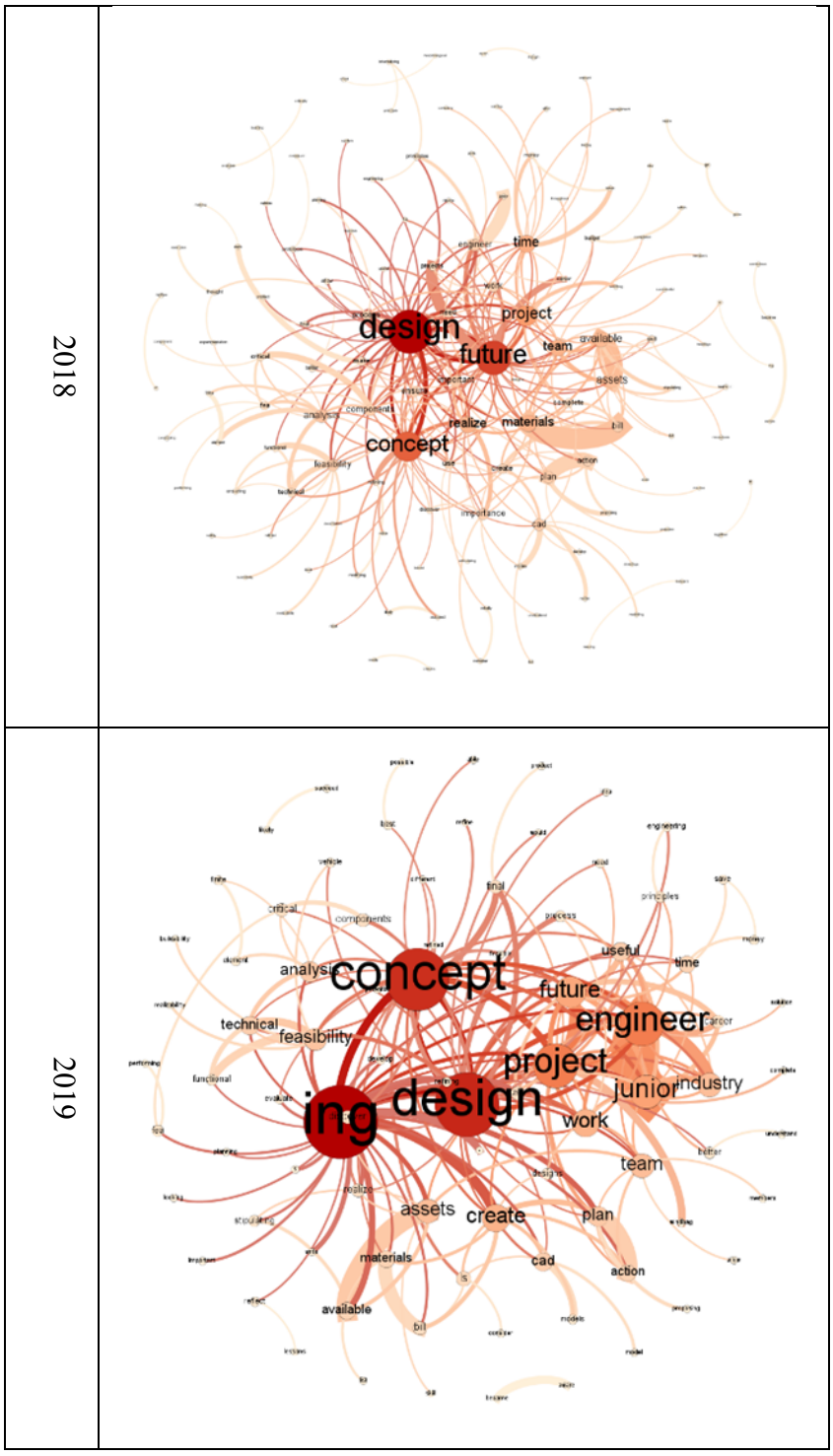
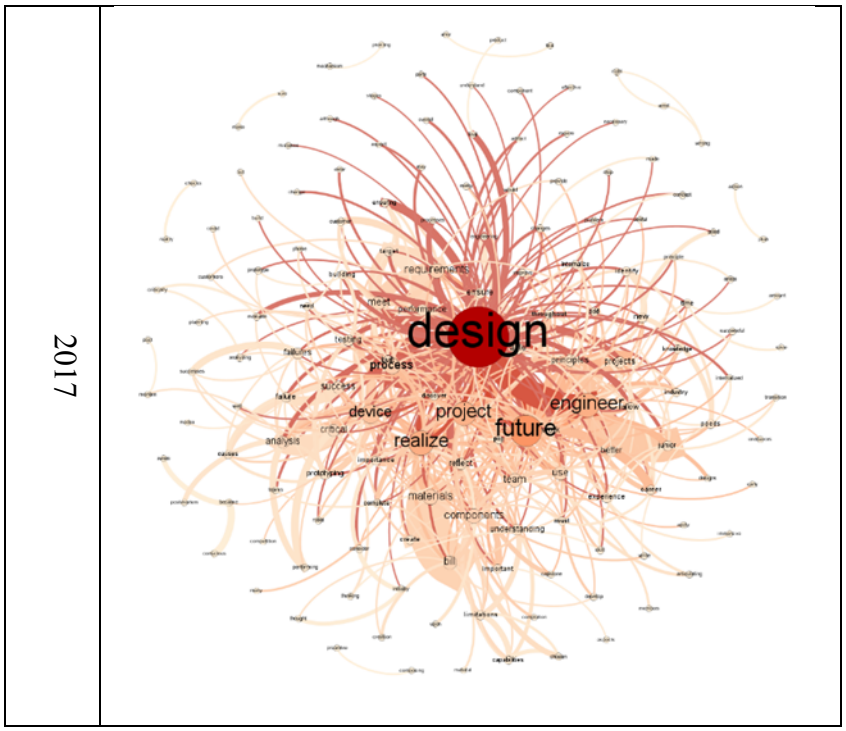


Figure 6.11 Text network results on Assignment 4

In Assignment 4, students are required to realize the designing prototype and test it. The work of Assignment 4 is based on Assignment 2 and 3. Students' design concepts in Assignment 2 and 3 will be realized in Assignment 4 and verified in Assignment5. So the learning statements in

Assignment 4 are the expansion of Assignment 2 and 3. There are some conclusions summarized by comparing the visualization results of Text Network between 2017, 2018, and 2019 :

1) In Assignment 4, the attention of students changes to the word of ‘design’. The word of ‘design’ becomes the most frequent word to connect other words in all results of three years. Students’ attention is focusing on the realization of design.
2) The word of concept is smaller than the word of design in 2017 and 2018. But in 2019, the words of ‘design’ and ‘concepts’ are almost same size. With instructors’ guiding, students are more concerning about the design concepts in 2019.



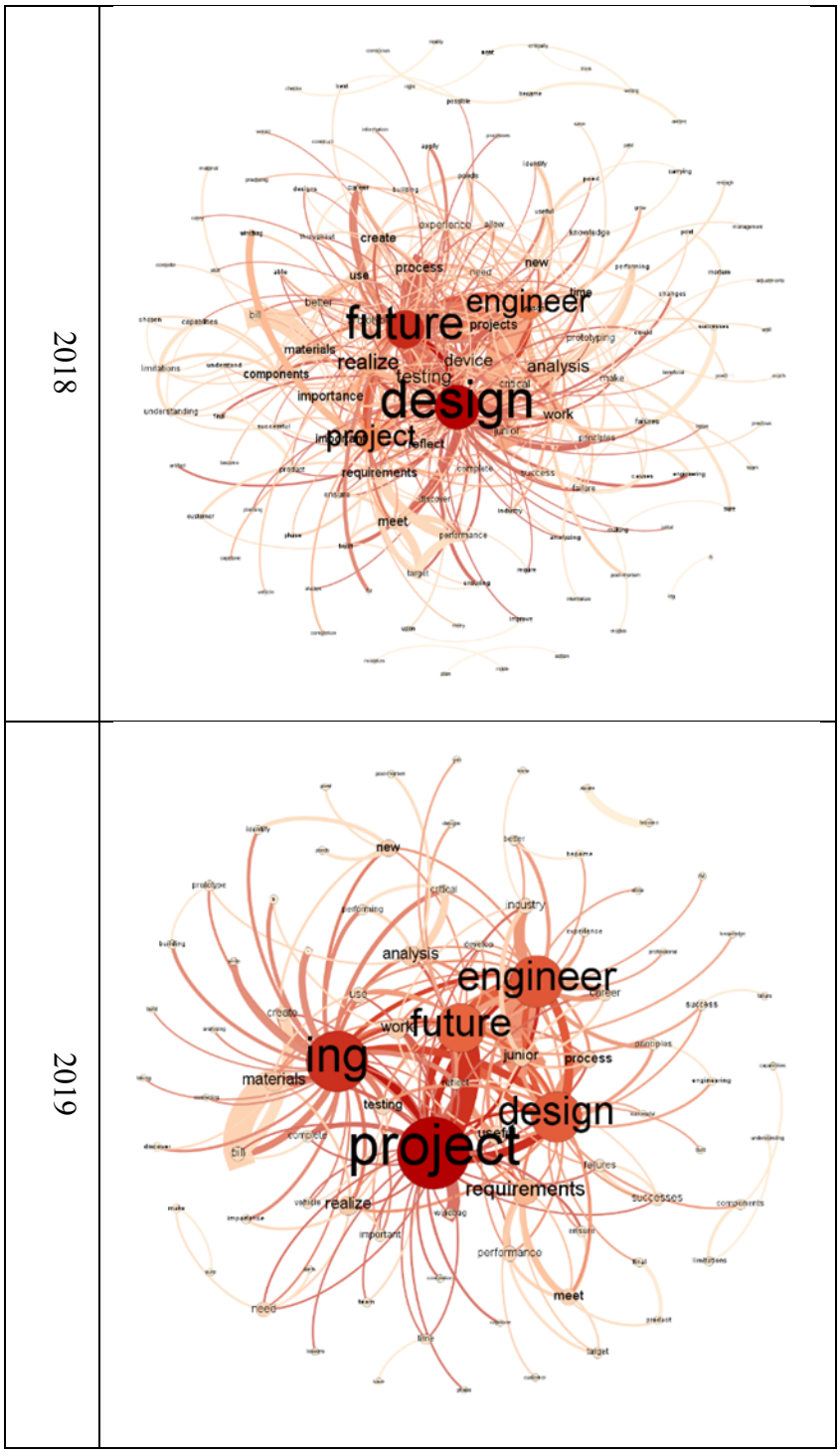


Figure 6.12 Text network results on Assignment 5

Assignment 5 is the whole verification of students' project in the course. In Assignment 5, students would get the products' accomplishment by attending the prototype competition. Instructors change the course booklet every year based on the students' reflection and learning of past year.

In 2019, there are some evident changes between the assignments and the relevant target POED. POED of Prototyping, testing and post-mortem analysis are renewed to connect Assignment 5 for students to learn and apply. From the visualization results of Text Network, there is not any finding to relate the changes' showing. So deeper analysis is needed in the future of the text mining methods to analyze students' learning statements.

6.4 VALIDATION THROUGH RESULTS OF 2020

In course AME4163, two instructors are teaching in two sections with vast numbers of students. Before 2020, the course lectures are given in in-person classes, and instructors will communicate with each student through tutorials many times during the course. The course is required a limited number of students in one section for students to get the best learning. In 2020, because of the COVID-19 pandemic, students were learning in online classes. The lectures are taught together with two sections in 2020 but separately in two classes by two instructors in 2017, 2018, and 2019. Based on this, it is hypothesized that students' learning statements in different years could reflect this change theoretically. With the analysis of text mining methods, this hypothesis through different visualization methods is verified.

In the thesis, different text mining methods and visualization methods are used to analyze students' reflection, learning statements that present students' learning, with intuitive graphs of word cloud, radar chart, line chart, and text network. Through the visualization results from 2017 to 2019, it is found that the analysis results of students' learning statements are not consistent with students' grades in Assignment 4. This conclusion helps instructors review the course booklet and find the issue of requirement description in Assignment 4. The table for Scaffolding the POED and the Assignments are changed in 2020, especially in Assignment 4. The POEDs which are proposed for Assignment 4 are revised to POED1d, POED4a, POED4b, POED4c. These changes are supposed to match the changes from students' reflection of 2020. With new visualization results of 2020, these two hypotheses will be verified and explained in detail.

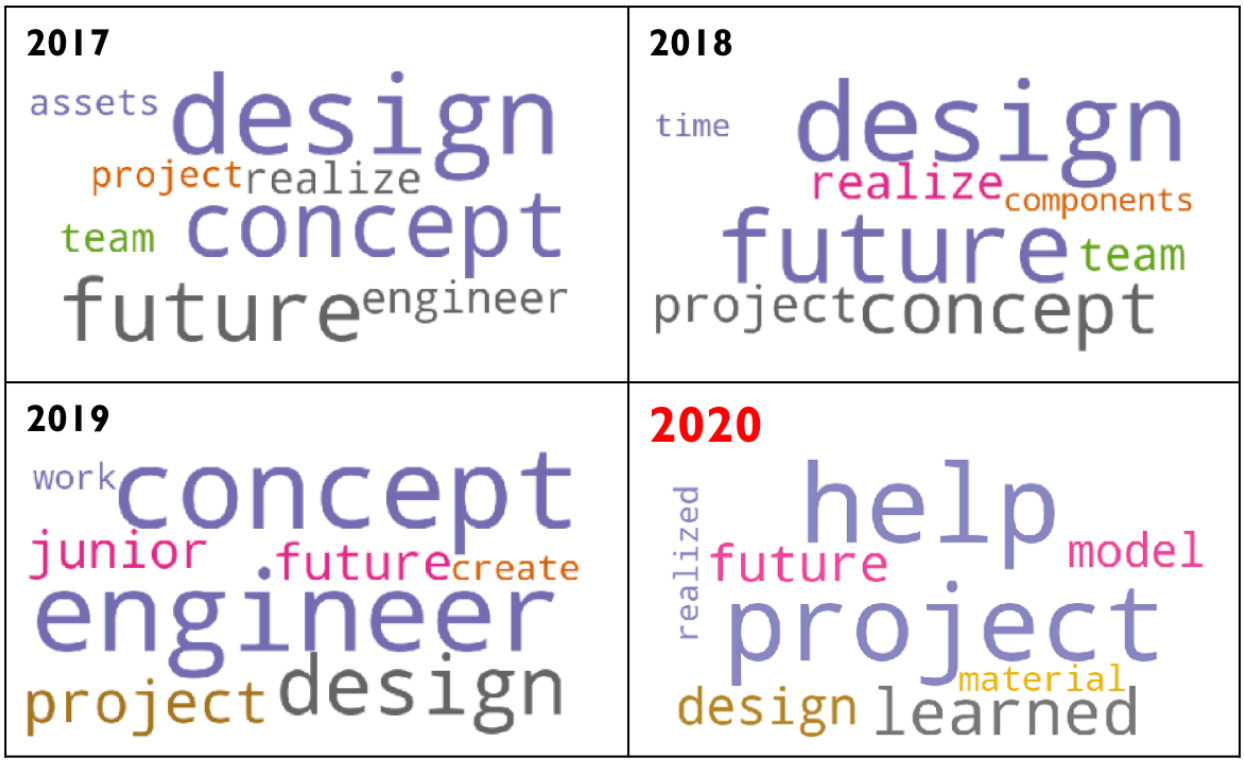


Figure 6.13 The Word Clouds of Assignment 4 in 4 Years

In the thesis, through analyzing students' learning statements of 2020, the text mining methods, such as Text Frequency Method, Text Similarity Method, and Text Network Method are verified that these results can be used to help the course instructors easily evaluate students' learning, find out the weakness parts of the course curriculum, and improve the course. From the text similarity results of 2020 with two sections in Figure 6.13, the text similarity between students' learning statements and target POED in Assignment 4 has risen in the whole course assignments, which means that students internalize the principles of engineering design in prototyping and testing deepened by using the revised course booklet of 2020. The internalized reflection from students is consistent with instructors' expectations. The text network results of Assignment 4 also verity this conclusion, which is that students focusing is matching instructors' course goals.

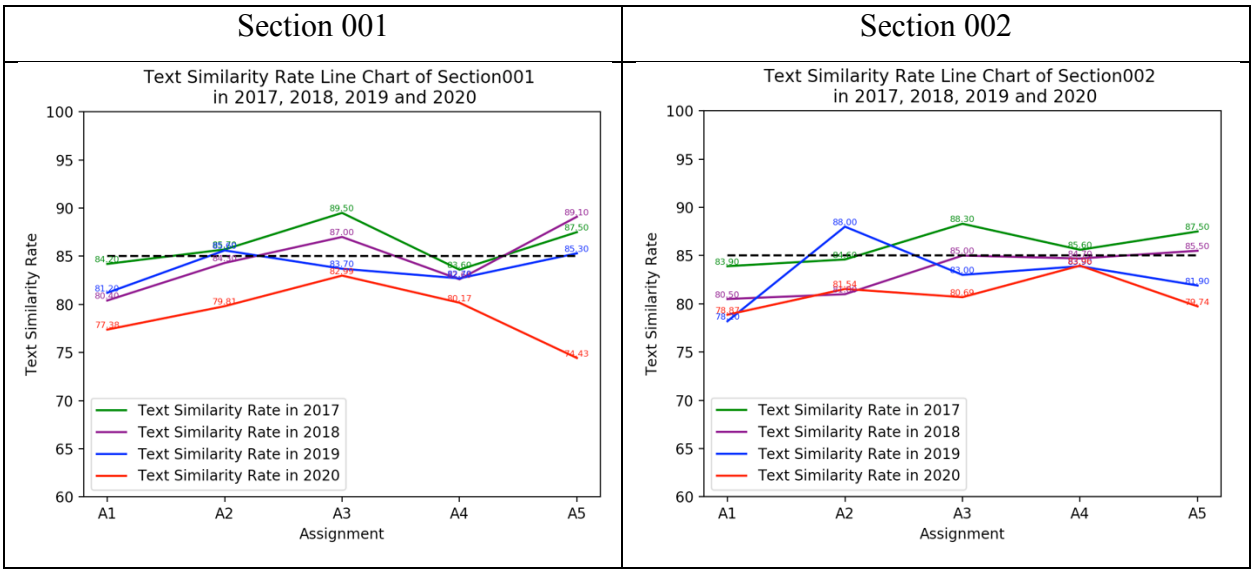


Figure 6.14 The Text Similarity Results in 4 Years

In this thesis, text mining methods are used to analyze the students' reflection in the engineering design course, for example, students' learning statements, with different text mining methods and visualization methods, and get multiple visualization graphs. These visualization graphs are used to help instructors evaluate students' learning, find out the weak parts to revise, and summarize the course influence for students' future career. Through the conclusions and insights from the generated visualization results of four years, the course is improved for students to achieve the competencies of self-learning and self-reflection as instructors expect.

6.5 ON VERIFICATION AND VALIDATION – EMPIRICAL PERFORMANCE VALIDITY (EPV)

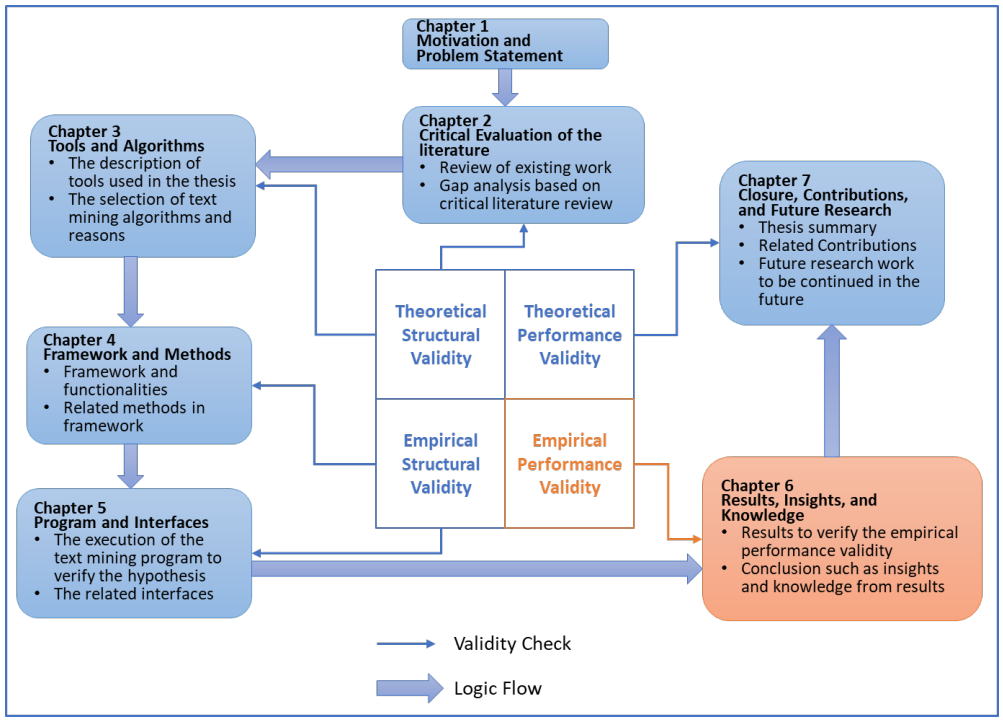


Figure 6.15 Validation Square of Chapter 6

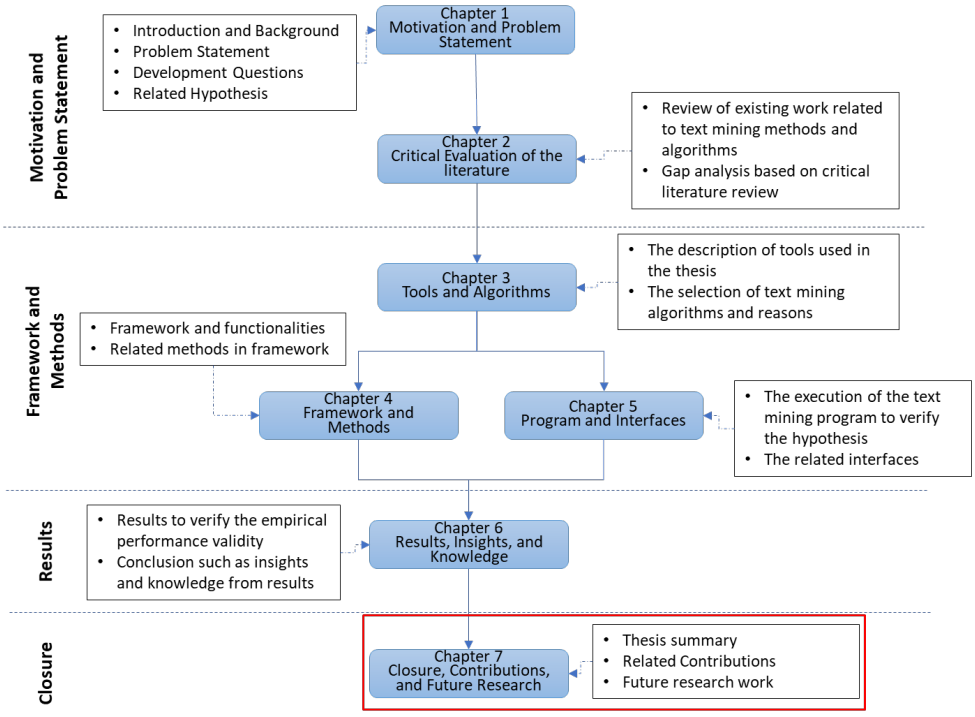
In this chapter, it is presented different visualization results which are generated by the text mining program, which include the histogram and word cloud from Word Frequency Algorithm, the radar chart and line chart from Text Similarity Algorithm, and the text network to present the connections of word-pairs in students' learning statements. These results, conclusions, and insights help us to verify the question in Empirical performance validity – *Does the application of the method to the sample problems produce practical results?*

- In Section 6.1, 6.2, and 6.3, there are different results, like word cloud, radar chart, and text network. These results are appropriate for testing the hypothesis - By designing an integrated framework with multiple text mining algorithms and implementing the framework in a program, the mining results could be visualized and provide insights to instructors.
- In Section 6.1, 6.2, and 6.3, it is concluded the comments and insights from obtained results of the text mining program. These insights help instructors to find out the weakness parts of the course for improving the future course. Based on the extended conclusions and insights, I

can validate the hypothesis of Empirical performance validity in validation square.

- In Section 6.4, more insights and analysis is concluded from the visualization results in Section 6.1, 6.2, and 6.3. These analysis and discussion would lead to my future work to explore more text mining methods to analyze other text contents, such as take aways. The way forward are presented in next chapter to verify the question in Theoretical performance validity.

CHAPTER 7 CLOSURE



In Chapter 6, multiple types of visualization graphs are used to reflect students' learning based on their learning statements. In this chapter, the closure of the thesis is presented. In Section 7.1, development questions, hypothesis, and gaps in the thesis are summarized. In Section 7.2, the relevant contributions to different stakeholders are discussed. In Section 7.3, the 'I' statements with self-reflection and self-assessment are presented. Some future research work are listed in Section 7.4.

7.1 A SUMMARY OF THE WORK

In Section 1.3, the following primary development question is posed with the relevant frame of reference:

> *How can a text mining program be used to allow instructors to gain insights from the original text source?*

This primary development question is further elaborated on by asking the following three sub-questions:

Sub Question 1: What is the appropriate method for handling large amounts of text data in the program?

Sub Question 2: What is the way for comprehensive mining of the learning statements to enable one to obtain meaningful results?

Sub Question 3: How to visualize the text mining results to facilitate instructors gaining new knowledge from the learning statements?

With critical review of literature in engineering design education domain and text mining domain, there are three corresponding gaps to be analyzed and resolve. By proposing the appropriate hypothesis, the primary development question and sub-questions are answered and validated from four theoretical and empirical, structural and performance validity perspectives. In Figure 7.1, it is the summary of Research Questions, related gaps and hypothesis.

Table 7.1 Summary of Development Questions in the Thesis

Thesis Development Questions	**Primary**	**Question:** How can a text mining program be used to allow instructors to gain insights from the original text source?
		Related Hypothesis: By designing an integrated framework with multiple text mining algorithms and implementing the framework in a program, the mining results could be visualized and provide insights to instructors.
	Secondary	**Gap 1:** Formalization of unstructured and heterogeneous textual documents
		Sub question 1: What is the appropriate method for handling large amounts of text data in the program?
		Hypothesis 1: A function for users to configure extraction rules can support users to deal with the large amounts of learning statements data.
		Gap 2: Generation of meaningful results from the text contents
		Sub question 2: What is the way for comprehensive mining of the learning statements to enable one to obtain meaningful results?
		Hypothesis 2: Integrating multiple text mining algorithms in a program can facilitate comprehensive mining of the learning statements from different perspectives.
		Gap 3: Intuitive representation of the text mining results
		Sub question 3:

		How to visualize the text mining results to facilitate instructors gaining new knowledge from the learning statements?
		Hypothesis 3: Using visualization tools such as word cloud, histogram, text network, and radar chart can help instructors gaining new knowledge or insights from the learning statements.

7.2 RELEVANT CONTRIBUTIONS FROM THE WORK

The text mining program is designed to help instructors to analyze learning statements and other text documents objectively and efficiently. Through the implementation of the text mining program, instructors can easily find out the key components in student's learning statements, and gain insights from word clouds. With more text mining algorithms and visualization methods researchers will be able ascertain deeper insight into what students learn and how instructors can improve the next offering of their courses.

1) Relevance to students: Learning statements are one way for students to learn by reflecting on doing. We envisage this framework being augmented for students to get instant feedback on their submissions so they are able to reflect and self-correct / self-learn without assistance from their instructors.
2) Relevance to educators: For educators, students' learning statements reflect their learning in the course to help instructors evaluate students. The proposed text mining framework helps educators easily and efficiently find out the insights in the visualization results. Educators could use these insights to improve the future engineering course for better instructing.
3) Relevance to researchers: The text mining framework helps researchers to quickly understand students' learning in the engineering course with the visualization results of learning statements. Researchers would develop the text mining methods for more exploring in the engineering education domain. The text mining framework could be extended by researchers to other domains.

In the future, the text mining program will be modified to include additional algorithms to analyze the text, for example, K-means Clustering Algorithm, Text Classification Algorithm. With these algorithms in place we should be able to answer questions such as:

- What is the difference in learning by Junior Engineers registered in two sections of this course each being orchestrated by a different instructor?
- How can we improve the experience to enhance learning of the Junior Engineers?
- How can we identify students who are likely to shine in this course early on?
- What are the characteristics of a team that performs well in the assignments and the characteristics of a team whose robot is super?
- What will be the impact of rewording the POEDs in keeping with Bloom's Taxonomy?

7.3 "I" STATEMENT

Having summarized the thesis work in past sections and future work which will be presented in next section, the parts of self-reflection and self-assessment for this thesis are addressed in this section. In this section, "I" statement is used to assert about the values, judgments, and future vision for research.

7.3.1 Self-Reflection

From the technical perspective,

My thesis is based on the research that text mining framework can be used to analyze students' reflection for helping instructors evaluate students' learning and improve the course. By discussing the text mining framework from different perspectives, the development questions in this thesis are answered with theoretical and empirical structural validation square. With these research work, I present the values of my work and future vision from this work.

1) Success/Failure analysis which is to understand the key factors that lead to the success/failure of a project by analyzing students' summary of 'what does/doesn't work'. I present the visualization results to analyze the inherent contents of students' learning statements. The inherent contents of students' learning statements include the summarization of key components, the trends of students' learning and the relations in students' reflections, such as

experience, learning and value. Success/Failure analysis is one part of the inherent contents in students' reflections. In my future research plan, success/failure analysis can be used to understand students' project reflections.

2) Machine learning which is learning the patterns from well-performed groups by analyzing their project learning data. In this thesis, I use different text mining methods to analyzing students' learning statements, and these methods are all based on the words, phrases of the textual contents. By using the machine learning methods, more paragraph and texts can be analyzed as an integrated source to get more insightful results, such as the patterns from well-performed or bad-performed groups' reflections.
3) Semantics which is to deeply understand students' learning by semantic-based analysis. Semantic-based analysis is the supplementary of machine learning methods. Different semantic results help instructors deeply understand students' learning with right sentiments. Different semantic results with a same word reflect different conclusions. And semantic analysis is an important part in my future research plan.
4) Issue/Risk identification which is to extract key issues/risks by analyzing customer reviews on e-commerce platform. Risk identification is an extended application of the research work in this thesis. Customer reviews are the most important part of an e-commerce platform for manager to make decisions. Issue identification can be analyzed from the customer reviews to confirm the issues in the processing of customer operating the platform.
5) CBDS which is providing decision support by the quantification and visualization of textual contents

In the thesis, different text mining methods and visualization methods are used to analyze students' course reflection and generate conclusions that can be used for instructors to evaluate students' learning and locate the weak parts of the engineering design course to improve. It is hard for students to express their issues during the course learning. It is easy for instructors to evaluate whether students' learning meets their expectations by analyzing students' reflections. The manual analysis of students' reflections is time-consuming and consumes human resources because of vast amounts of documents and text contents. Therefore, in the thesis, I use automatic methods to analyze students' reflection from the quantitive perspective. Text mining methods are suitable to analyze students' structured reflections, for example, learning statements, to gain more insights for instructors to evaluate students' learning. In Section 6.1, 6.2, and 6.3, multiple visualization

results are generated by the computed data from the original structured textual contents in three years. These visualization results, word cloud graphs, text similarity radar charts, and text network graphs are concluded many useful insights. One of the insights is that students have some trouble learning Assignment 4 of 2019 because the text similarity rate of 2019 in both sections is lower than the rates of 2017 and 2018. In 2020, instructors revised the target POED for Assignment 4 and the relevant requirements for students. From the new visualization results of 2020 in Section 6.4, the conclusions are verified that the revised course booklet helps students more internalize the related POEDs. The analysis results of students' reflection in Assignment meet instructors' expectations. The chapters of the thesis verify the validation square in Section 1.4. The text mining program that integrates the text mining methods and visualization methods is used to analyze the structured textual contents quantitively. The intuitive results generated from the text mining program help instructors review students' learning in the course and judge whether students' learning results meet their expectations. In Section 7.1, I have summarized the answers to development questions presented in Chapter 1. More extended research questions are proposed to be answered in my future research work in Section 7.4.

7.3.2 Self-Assessment

The competencies that I developed during my thesis studies include:

1) The ability to find out a development question based on the current existing issues;
2) The ability to critically review other literature work and gap analysis;
3) The ability to propose the corresponding hypothesis to fill the gaps and answer the questions;
4) The ability to construct a framework to realize the proposed hypothesis;
5) The ability to verify and validate the research work for answering the development question;

Table 7.2 Self-assessment of Competencies Developed

Competency developed	Self-assessment
The ability to find out a development question based on the current existing issues;	To ascertain my ability for this competency, in my thesis, I have proposed a primary development question and three sub questions. The primary development question is proposed to resolve the current existing issues, too much time-consuming and human resource consuming for manually analyzing students ' reflection. And the primary development question is divided into three sub questions to resolve in a workflow for easily getting the insightful results.
The ability to critically review other literature work and gap analysis;	In engineering design education domain, I critically review other researchers ' works and find out experiential learning cycle is the suitable way for instructors helping students abstract their learning and utilize these learning into students' future career. And the literature review in text mining domain helps me integrate the suitable tools and methods to frame the text mining program for analyzing student' s triple structured reflection. Based on these critical review, gaps between existing words and the primary development question are analyzed to be filled.
The ability to propose the corresponding hypothesis to fill the gaps and answer the questions;	The corresponding hypothesis are proposed to fill the gaps and answer the question. These hypothesis are related to resolve three sub questions and construct the text mining framework in the processing from the original textual data to the visualization analysis results.
The ability to construct a framework to realize the proposed	With gap analysis and proposed hypothesis, I analyze the existing tools and methods to integrate a suitable

hypothesis;	text mining framework. There are four functions in the text mining framework. The function of data cleaning helps resolve the sub question 1 and formalize the unstructured documents. The function of text analysis is used to generate the cleaned data into the mining results. The function of result visualization is helping transform the mining results into the intuitive visualization results. With the text mining framework, the insights can be gained by instructors to evaluate students' learning and improve the engineering design course.
The ability to verify and validate the research work for answering the development question;	The verification and validation square is proposed in each chapter of the thesis, and discussed to verify and validate the research work. In Chapter 3, the proposed tools and methods are verified the research work from theoretical structural validity. In Chapter 4 and 5, the text mining framework and program are used to validate the empirical structural validity. In Chapter 6, the realized visualization results and related comments are presented to validate the empirical performance validity.

7.4 FUTURE WORK

7.4.1 New Questions

In the thesis, the primary development question is how can a text mining program be used to allow instructors to gain insights from learning statements of OU course: AME4163? A text mining program is hypothesized to help instructors interpret students' reflections and understand students' learning. For gap analysis, the existing work is reviewed from the engineering education and text mining perspectives. Researchers utilize different ways to evaluate students' learning for

developing students the corresponding competencies. Students abstract conceptualization with their learning during the experiential learning cycle. Students' reflections are generated as take away, learning statement and learning essay. With these reflections, engineering course instructors can quickly evaluate students' learning to confirm course value for students' future career. Researchers use different evaluation tools to analyze students' reflections. The reflections are mainly textual contents for students to complete with heterogeneous structure. The textual contents with heterogeneous structure are hard to handle with existing tools. Other researchers try to use the technologies of nature language processing to analyze these reflection results. The gaps in this thesis are that the existing tools are not suitable for analyzing students' learning statements in course AME4163. An integrated text mining framework is constructed to analyze the learning statements and visualize these analysis results. The relevant tools and methods of the text mining framework are explored to deal with the textual data and implement the appropriate visualization results.

In Chapter 3, the foundation tools for developing the text mining program are described, and the corresponding methods of the text mining framework are presented to realize the functions: data cleaning, data management, text analysis and visualization results in Chapter 4. The development of text mining program in Chapter 5 helps to verify the empirical validity of the work. Different visualization results generated by the text mining program are presented in Chapter 6. The statistical results of word cloud emphasis students' focusing during different stages of the engineering design course which are presented in Section 6.1. In Section 6.2, the visualization results of radar chart and line chart reflect the comparison of text similarity between different years and sections. These comparison conclusions facilitate instructors to discover the shortage of the lectures in the course. More statistical analysis results are proposed in Section 6.3, and the visualization results of text network present the connection of semantic word phrase in students' learning statements.

The work of realizing the text mining framework and implementing the text mining program answers the primary development question of the thesis from empirical structured perspective. The statistical results and relevant conclusions verify the thesis work with empirical performance validity. The whole statistical results in the thesis provide meaningful insights for instructors to improve the course. Actually, more insightful results may be explored from the learning statements by other text mining and visualization methods. With the relevant hypothesis, some other questions

are intended for exploration in future work. The following questions which can be used to generate the future plan are listed as:

1) What are the expected insights from more text mining and visualization methods of the integrated text mining framework to analyze students' reflection in engineering design courses?
2) What are the suitable text mining methods and visualization methods can be selected to analyze students' reflection?
3) How does the integrated text mining framework realize to match the most suitable methods for internalizing students' reflection?
4) How can the text mining framework be used to analyze more textual contents for other research domain?

Addressing these questions can be served as the foundational motivation for the future work. For developing the relevant methods and results to answer these questions, there are the relevant hypothesis are presented in Section 7.4.2.

7.4.2 The Relevant Hypothesis

In the thesis, the text mining framework is constructed with the relevant methods of different functions to analyze the textual data for getting insightful visualization results. The future work is tended by extending the utilities of the text mining framework to answer more new questions and create new knowledge. In Table 7.2, it is listed as the connection between new questions and associated hypotheses.

Table 7.3 New Questions and Associated Hypotheses

New Questions	Associated Hypotheses
What are the expected insights from more text mining and visualization methods of the integrated text mining framework to analyze students' reflection in engineering design courses?	1) The predicted classification can be implemented from the text mining framework for users as a reference material. 2) The comparison between students' take away and learning statements can be analyzed from the text mining framework

	to explore evaluating students in the engineering design courses.
What are the suitable text mining methods and visualization methods can be selected to analyze students' reflection?	The expected results implemented by different text mining and visualization methods can be selected to meet the expected goals.
How does the integrated text mining framework realize to match the most suitable methods for internalizing students ' reflection?	The pre-processing step is designed to collect the features of the original textual contents. These features can be used to match the suitable methods for getting insightful results and internalizing the original textual contents.
How can the text mining framework be used to analyze more textual contents for other research domain?	Different configure rules can be designed to deal with different textual contents of different research domain to get the visualization results and gain insights from these results.

7.4.3 Related Work to Tie to CBDS

CBDS is the platform for engineering design researchers to create required templates and simulate the implemented progress of the templates. The functions and methods of the text mining framework can be used to optimize some modules of the CBDS platform. The following work is planned to tie to CBDS:

1) The text mining template can be created in the CBDS platform to integrated into other templates for realizing the certain task.
2) The functions of data cleaning and data management can be used to deal with the description of the templates.
3) The functions of text analysis and visualization results can be used to statistic and visualize the required data.

7.4.4 The Future Plan

By following from the work completed in the thesis, which includes literature review, the text mining methods, related text mining program, multiple visualization results, new proposed questions and hypotheses, it helps to plan the future work for next step. The future plan will focus on verifying new hypotheses and creating new knowledge based on new findings and results. Table 7.3 is the summary of hypotheses for new questions and related tasks which need to be organized in the future research plan.

Table 7.4 Summary of Hypotheses for New Questions and Related Tasks

Hypotheses for New Questions	Tasks
1) The predicted classification can be implemented from the text mining framework for users as a reference material. 2) The comparison between students' take away and learning statements can be analyzed from the text mining framework to explore evaluating students in the engineering design courses.	a) By reviewing the existing literature work, find out the suitable text classification algorithms to integrate into the text mining framework. b) Adjust the functions of the text mining framework to support for analyzing students' take away and learning statements and comparing the visualization results to gain more insights and create new knowledge.
The expected results implemented by different text mining and visualization methods can be selected to meet the expected goals.	By reviewing and testing different text mining algorithms and visualization methods, sort out the expected results to match the requirements.
The pre-processing step is designed to collect the features of the original textual contents. These features can be used to match the suitable methods for getting insightful results and internalizing the original textual contents.	a) Develop the pre-processing step into the text mining framework. b) Implement the previous and future data in the improved text mining framework to get different visualization results. c) Statistic the matching table between data

	features and relevant methods for the text mining framework to choose.
Different configure rules can be designed to deal with different textual contents of different research domain to get the visualization results and gain insights from these results.	a) Collect different data in different domain to analyze in the text mining framework. b) Add different configure rules for these data to clean and save, different data are implemented with suitable methods to gain insights and create new knowledge.

From the table with tasks relating to new hypotheses, the future work will be extended from current text mining program into a new integrated system. Students' reflections include take aways and learning statements. In this thesis, learning statements are the analyzed data to gain insights for instructors in the course. In the future plan, take aways will be used with learning statements to analyze for both instructors and students. In the future work, the integrated text mining system will be used by both instructors and students to gain different insights. For instructors, the new integrated text mining system is improved to get more findings and helps them improve the course in the future with more details in different lectures and assignments. For students, the new integrated text mining system helps them assess their learning by themselves, and improve their competencies of self-reflection and self-learning. In the future plan, the tasks will be completed to answer the new questions.

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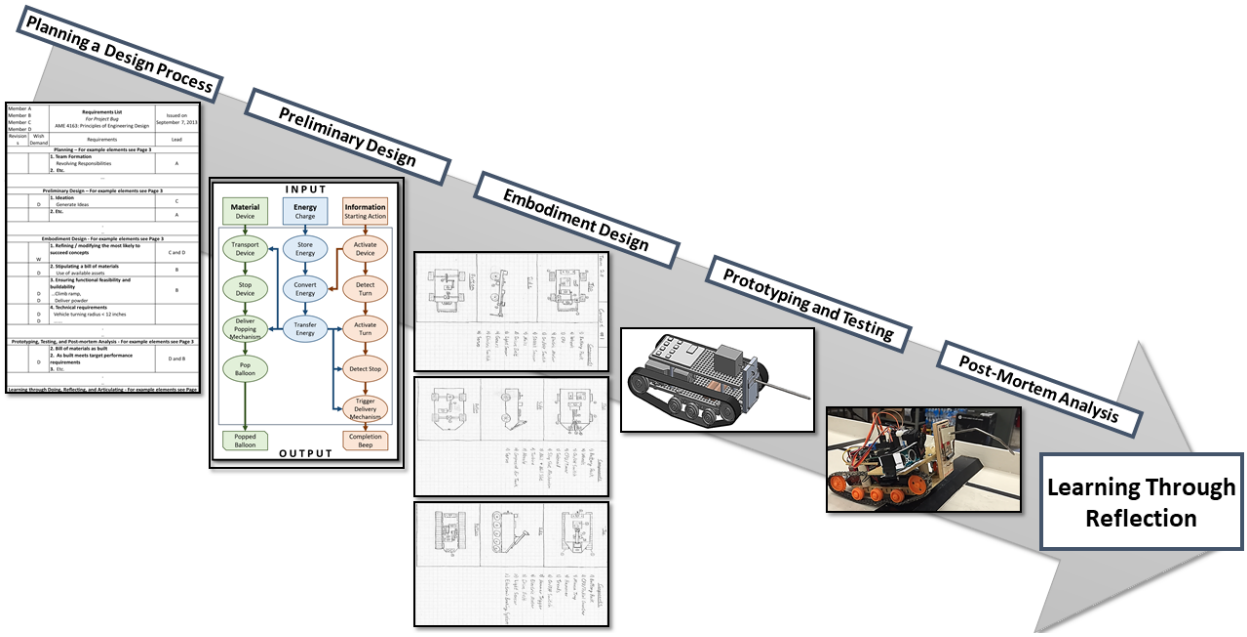
APPENDIX.A THE COURSE BOOKLET OF AME4163 ON FALL 2019

Fall 2019

AME4163: Principles of Engineering Design

Course Booklet



Instructors:

XXX

Teaching Assistants:

XXX

Disclaimer: This booklet has been developed primarily for the convenience of AME4163 students. The documents contained in this booklet are subject to possible changes throughout the semester which may be necessitated by circumstance. Students are responsible for keeping track of these changes as they are announced.

CONTENTS

I. COURSE SUMMARY

WHAT THE COURSE IS ABOUT?

1. Internalizing the principles of engineering design and learning how to identify and develop career sustaining competencies
2. Learning through doing (reading, designing, building, testing, and post-project analysis), reflecting, and internalizing the principles of engineering design
3. Learning to frame, postulate a plan of action, and then implement that plan of action for the capstone project in AME4553 in Spring 2020
4. Transitioning from being a student to a junior engineer in a company

PRINCIPLES OF ENGINEERING DESIGN

6. Planning a design process
    a. Forming a team
    b. Accepting and executing a team contract to stipulate ethical guidelines to decision making and problem resolution
    c. Understanding the problem and framing the problem statement
    d. Proposing a plan of action
7. Preliminary design
    a. Ideating and generating concepts
    b. Developing concepts to ensure functional feasibility, ensure realizability (technical feasibility)
    c. Evaluating the concepts (functional feasibility, technical feasibility) and identifying that system concept which is most likely to succeed
8. Embodiment design
    a. Refining / modifying the most likely to succeed concept through technical analysis, experimentation and thought exercises
    b. Stipulating available assets
    c. Ensuring functional feasibility, technical feasibility, realizability (buildable within budget and with available skills), and safety
9. Prototyping, testing and post-mortem analysis
    a. Creating a bill of materials as built, including an understanding of the limitations and capabilities of the chosen components
    b. Ensuring that the design as built meets target performance requirements
    c. Performing a critical analysis after device prototyping of causes of success and failure
10. Learning through doing, reflecting and articulating
    a. Critically evaluating the processes of designing, building, and testing
    b. Articulating, using learning statements, the Principles of Engineering Design that you have internalized
    c. Identifying new POED and carrying that knowledge into future projects and experiences

TARGETED NON-TECHNICAL, CAREER SUSTAINING COMPETENCIES

In AME4163 we provide an opportunity for you to develop the following competencies for use in Capstone (AME4553) and beyond:

1. The ability to learn by reflecting on doing
2. The ability to speculate on future trends and pose questions worthy of investigation

3. The ability to make engineering design decisions in the face of limited information
4. The ability to adapt to new circumstances such as a new design team or problem
5. The ability to introspectively self-assess to improve as a designer

II. COURSE INFORMATION

CONTACT INFORMATION

Instructors

XXX XXX

Teaching Assistants

XXX XXX

EMAIL AND FILE NAMING PROTOCOLS

We expect you to follow the submission protocols listed in each assignment. The salient features are summarized below.

Emails: We expect you to use the following convention for all emails

Email on behalf of team

In subject line. AME4163 – Assignment # – Team Number

OR

In subject line. AME4163 – Nature of Query – Team Number

Email on behalf of individual

In subject line. AME4163 – Assignment # – Family Name

OR

In subject line. AME4163 – Nature of Query – Family Name

Assignment Submissions: We expect you to use the following file naming convention on all submissions

AME4163_xx_yy

Where 'xx' represents the assignment number or submission title and 'yy' your Team Number (for team submission) or Family Name (for individual submission). Team number yy has two components. Examples: 1.10 (Section 1, Team number 10). 2.09 (Section 2, Team Number 9)

Notes on communication protocols

1. Be sure that there is no space between the 'AME' and '4163' portions of the subject line.
2. In the body of the email, please remember to include a phone number that the junior engineer can be reached at.
3. We expect you to combine all elements of an assignment into ONE file. Submissions are expected in Word. You may upload a pdf file as well.
4. We plan to respond to every email. If you do not get a response in a timely manner, please resend the email with "Gentle Reminder" at the start of the subject header.
5. Please ensure that the Assignment number, Team number or Family name of individual and page numbers appear in the footer of each Word and pdf document.

ASSIGNMENT TEMPLATES

In this course, assignment templates are provided for your use. In general, they are structured as follows: Cover Page/Self-Grading Rubric, Assignment body, and Appendix. After your team has completed the assignment, but not yet submitted the document, you MUST complete the self-grading form and fill in the rubric. The self-grading form serves as the assignment cover page. This should serve as a reflective exercise and potential final check before submission. In some instances, we will request that you put certain information in the appendix and, at other times, your team may see fit to do so. In any case, appendices should be given some sort of descriptive title such as "Appendix A: Extended Gantt Chart" rather than simply "Appendix A". All appendices need to be referenced in the body of the assignment. You need to put the appendix in the context of the assignment, for example, "In this appendix we include the calculations to support decisions embodied in Section X."

Importantly, we require that your team, though it may personalize the document in many ways, NOT alter the document headings provided in the template. We use an automated tool to collect certain information from assignment submissions and altering the heading format frustrates this effort. In some cases, heading text only may be altered. These can be identified by the use of brackets in the template. For example, a header titled "[TEAM MEMBER A]" may be changed to "Jane Q. Student."

POLICY INFORMATION

As this is a design course, we encourage you to collaborate and discuss assignments and projects with your fellow classmates. However, we will not tolerate copying of assignments, projects, or reports. For assignments and projects, the deadlines are rigid (with some exceptions for emergencies).

In AME4163 we will make use of the Canvas platform. Tutorial information on using the site will be uploaded to the main page of the course on Canvas, with further support available at ou.edu/ouit.

Reading materials are made available online (through Canvas) and are offered to add context to the assignments and project goals. This material is provided for teams and individuals to leverage in their completion of assignments. Citations are required for all material used in assignments.

For all assignments, a standard of professionalism is expected and required. This includes submission of all assignments in Word and if you choose PDF as well, utilization of all outlined communication protocols (this includes obeying file naming conventions outlined in this booklet), and the following submission requirements: page numbers, section headers, diagrams and figures (where appropriate) correctly labelled, and any references cited. These professionalism requirements will account for a percentage of the submission grade.

If you require accommodation on the basis of disability, please contact one of the instructors or teaching assistants. More information on OU's disability accommodation policy may be found at: http://www.ou.edu/eoo/policies-procedures/disabilities.html

PRINCIPAL GOAL

Our goal, in this course, is to provide an opportunity for you as a junior engineer to internalize the Principles of Engineering Design and to develop competencies (see Page 1) that you need to hit the road running as a junior engineer in AME4553 and in industry in nine months' time. Note the phrase "junior engineer." In your courses up to this point, you have largely identified and been identified as "students." We make the conscious choice instead to use the phrase "junior engineer" to highlight the fact that you are now at a stage of technical competency and maturity that merits treatment more akin to that you will likely experience in your careers. Further, we intend to act largely as mentors or coaches to you throughout the design project. Internalizing this perspective, we believe, will aid in you in two ways. First, we aim to provide you the tools and guidance which will enable you to meet the challenge presented in this course and are therefore available as resources. Second, we intend to prepare you in this course for your Capstone design experience (AME4553) in the Spring semester. In AME4553, you will be addressing engineering challenges (primarily for corporate sponsors) for which you will be responsible for professional work. Accordingly, in AME4163, we expect you to learn how to act like practicing junior engineers in professional settings. We therefore put it to you in AME4163, in preparation for your work in Capstone and your careers, that you should endeavor to visualize yourselves as "junior engineers" as you work with your teams this semester.

In AME4163, you must complete a semester-long design, build and test project with a team of your colleagues. In this course, we focus on learning and not just on how well your project device performs on the day of the competition. By the time you begin your Capstone design projects in Spring, you should be able to:

i. Plan a design process by understanding requirements, implement that process, evaluate the outcome, and identify improvements to that process.
ii. Generate, evaluate, and develop design concepts by applying knowledge of science, engineering techniques, and manufacturing principles.
iii. Use analysis and simulation tools to understand design performance and then improve the design.
iv. Generate solid models and engineering drawings of the design using 3D modelling software.
v. Prototype the design.
vi. Learn through reflecting on doing (for example, design, build, test, read, write, etc.) and experiencing (for example, working in a team, getting feedback from mentors).

As we intend to treat each of you like a junior engineer in a company, we expect you to act like one. Consider how you frame your questions to your mentors. We encourage frequent questions to improve your understanding, but your questions should be commensurate with your new status. A student asks questions like "how can I get an A?" or "what do you want me to do in this assignment?" A junior engineer thinks deeper and instead asks questions which will help them learn and grow as engineers. So, while we encourage frequent questions, we ask that you stop and think before asking questions which could instead be more readily answered by reading through your booklet.

ASSIGNMENT LIST AND GRADE BREAKDOWN

*A1: Planning a Design Process (*See Page 16)

1. Self-grades as per rubric with justification shown in rubric that follows the self-grading sheet.
2. Team Skill Inventory and Team Prospectus
3. Team Contract Understanding
4. Problem Statement
5. Project Schedule
6. House of Quality
7. Requirements List
8. Take Aways and Learning Statements. Do NOT change section header for this item in template.

Grade: See Assignment 1 Grade Breakdown
10% of total
Target POEDs: 1a, 1b, 1c, 1d, and 5b. See Page 1 and table on Page 7.

A2: Preliminary Design (See Page 25)

1. Self-grades as per rubric with justification shown in rubric that follows the self-grading sheet.
2. Function Structure
3. Reality Check
4. Morphological Chart
5. Concept Generation
6. Plus, Minus, Interesting
7. Take Aways and Learning Statements. Do NOT change section header for this item in template.

Grade: See Assignment 2 Grade Breakdown
10% of total
Target POEDs: 1d, 2a, 2b, 2c, and 5b. See Page 1 and table on Page 7.

A3: Embodiment Design, Pt. I (See Page 29)

1. Self-grades as per rubric with justification shown in rubric that follows the self-grading sheet.
2. Available Assets
3. Critical Evaluation of Concepts
4. Establish Evaluation Criteria
5. Go/No-Go Analysis
6. Reduce the Number of Concepts, Critical Analysis, Justification
7. Preliminary Bill of Materials
8. Take Aways and Learning Statements. Do NOT change section header for this item in template.

Grade: See Assignment 3 Grade Breakdown
10% of total
Target POEDs: 1d, 3a, 3b, and 5b. See Page 1 and table on Page 7.

A4: Detailed Design (See Page 33)

1. Self-grades as per rubric with justification shown in rubric that follows the self-grading sheet.
2. Refined Concept Description
3. CAD Models
4. Bill of Materials
5. FEA of Critical Components

6. Take Aways and Learning Statements. Do NOT change section header for this item in template.

Grade: See Assignment 4 Grade Breakdown
15% of total
Target POEDs: 1d, 3a, 3b, 3c, and 5b. See Page 1 and table on Page 7.

Project Demonstration and Reviews

1. Mid-term Design Review
2. Prototype Update
3. Prototype Demonstration/Competition

Grade: See Project Grading Scoresheet 15% of total
Target POEDs: 4a, 4b, and 4c, See Page 1 and table on Page 7.

A5: Post-Mortem Analysis (See Page 37)

1. Self-grades as per rubric with justification shown in rubric that follows the self-grading sheet.
2. Preamble
3. Design Process
4. Changes to the Design Process
5. Design Artifact
6. Changes to the Design Artifact
7. Take Aways and Learning Statements. Do NOT change section header for this item in template.

Grade: See Assignment 5 Grade Breakdown
10% of total
Target POEDs: 4a, 4b, 4c, 5b, and 5c. See Page 1 and table on Page 7.

A6: Semester Learning Essay (See Page 41)

1. Self-grades as per rubric with justification shown in rubric.
2. Take Aways and Learning Statements. Do NOT change section header for this item in template.

Grade: See Assignment 6 Grade Breakdown
10% of total
Target POEDs: 5a, 5b, and 5c. See Page 1 and table on Page 7.

A7: Capstone Plan of Action (New Teams) (See Page 43).

Pattern Assignment 7 after Assignment 1 of AME4163.

1. Document Format and Problem Statement
2. Background Information
3. Team Understanding
4. Requirements List
5. Question for Sponsor
6. Plan of Action
7. Important Milestones
8. Critical Evaluation
9. Take Aways and Learning Statements. Do NOT change section header for this item in template.

Grade: See Assignment 7 Grade Breakdown
10% of total

Target POEDs: 1a, 1b, 1c, 1d, 5b, and 5c. **See Page 1 and table on Page 7.**

Short Exercises and Miscellaneous
10% of total
1. Attendance and participation
2. Ethics exercise
3. CFD/FEA/CAD short assignments

Note: All assignments outlined above also include a required level of professionalism, outlined specifically in each assignment breakdown and more generally in the "Policy Information" section on Page 3 of this booklet.

ASSIGNMENTS AND PRINCIPLES OF ENGINEERING DESIGN

To structure your learning over the course of this project and to further aid in your internalization of the Principles of Engineering Design (POED), the following table is provided in which we map the POED to the specific assignments in which they appear. Leverage this information as you go through assignments and prepare your Take Aways and Learning Statements. Note that these are the instructor learning targets for each assignment; you are encouraged to reflect on connections between POED and assignments not made explicit by this chart.

Assignment	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Description / **Target POED**	***Given:*** Story, Team Contract ***Provide:*** Problem Statement, POA, HOQ, Req. List, LS	***Given:*** Prob. Statement, HOQ, Req. List. ***Provide:*** Function Structure, Morph. Chart, 6 Concepts, PMI, Failure, LS	***Given:*** Concepts, PMI, Failure ***Provide:*** Go/No-Go from 6 to 2, Bill of Materials, Select Concept, LS	***Given:*** Selected Concept ***Provide:*** Geometry analysis, CAD model, refined Bill of Materials, Buildability, Report, LS	Post-Mortem Report	Semester Learning Essay	Capstone Plan of Action
1a	✖						✖
1b	✖						✖
1c	✖						✖
1d	✖	✖	✖	✖			✖
2a		✖					
2b		✖					
2c		✖					
3a			✖	✖			

3b			×	×			
3c				×			
4a					×		
4b					×		
4c					×		
5a					×	×	
5b	×	×	×	×		×	×
5c					×	×	×

See Page 1 of this booklet for details on the specific Principles of Engineering Design (POEDs)

CLASS SCHEDULE

Week	Date	Section 001	Section 002	Item Due	Notes
1	8/20	Course Introduction Discussion of Booklet	Course Introduction Discussion of Booklet		001: SEC N0202 002: GLG 127
	8/22	Steps in Design Processes Designing and Managing the Design Process	Steps in Design Processes Designing and Managing the Design Process	Reading: David Kolb, Competencies	001: SEC N0202 002: GLG 127
2	8/27	Understanding Customer Needs - Creating House of Quality and List of Requirements	Take Away Learning Statement Construction Semester Learning Essay	**DUE 8/28 by 11:59 PM: Team Formation Submissions**	001: SEC N0202 002: GLG 127
	8/29	Take Away an Learning Statement Construction Semester Learning Essay	Understanding Customer Needs - Creating House of Quality and List of Requirements	Reading: Bloom's Taxonomy, Learning Statements	001: SEC N0202 002: GLG 127
3	9/3	Diversity and Professionalism Workshop, Part I			001 and 002: EPF 200
	9/5	Diversity and Professionalism Workshop, Part II			001 and 002: EPF 200
4	9/10	Function Structure Morphological Chart Assignment 2 Discussion	Function Structure Morphological Chart Assignment 2 Discussion		001: SEC N0202 002: GLG 127
	9/12	**No Class – Engineering Career Fair**		**DUE 9/13 by 11:59 PM: Assignment 1**	Register early to avoid waiting in line!
5	9/17	Value Engineering Attention Directing Tools	Value Engineering Attention Directing Tools		001: SEC N0202 002: GLG 127

	9/19	Go/No-Go Concept Selection Assignment 3 Discussion	Computer-Aided Design Methods and Approaches		001: SEC N0202 002: GLG 127
6	9/24	Computer-Aided Design Methods and Approaches	Go/No-Go Concept Selection Assignment 3 Discussion		001: SEC N0202 002: GLG 127
	9/26	Machine Shop Tour		**Due 9/27 by 11:59 PM: Assignment 2**	See Posted Schedule
7	10/1	Feedback: Mid-Term Design Review		Review Form	See Posted Schedule
	10/3	Feedback: Mid-Term Design Review			
8	10/8	**No Class – Work Day**			
	10/10	**No Class – Work Day**		**Due 10/11 by 11:59 PM: Assignment 3**	
9	10/15	**No Class – Work Day**			
	10/17	**No Class – Work Day**			
10	10/22	Feedback Team Prototype Update		During Review: Prototype or Frankenstein Prototype **Due 10/25 by 11:59 PM: Assignment 4**	See Posted Schedule
	10/24	Feedback Team Prototype Update			See Posted Schedule
11	10/29	**No Class – Work Day**			
	10/31	Capstone Project Announcements			001: SEC N0202 002: GLG 127
12	11/5	Project Demonstrations			See Posted Schedule
	11/7	Project Demonstrations			See Posted Schedule
13	11/12	Engineering Ethics	Engineering Ethics		001: SEC N0202 002: GLG 127
	11/14	**No Class – Work Day**		**Due 11/15 by 11:59 PM: Assignment 5**	
14	11/19	**No Class – Work Day**			
	11/21	**No Class – Thanksgiving Break**			
15	11/26	**No Class – Work Day**		**Due 11/27 by 11:59 PM: Assignment 6**	
	11/28	**No Class – Work Day**			
16	12/3	Dead Week **No Class – Work Day**			

	12/5	Dead Week **No Class – Work Day**	**Due 12/14 (AME4553 advisor discretion): Assignment 7**	All extension-granted work due by 12/6
17	12/10	Finals Week **No Class – Work Day**		
	12/12	Finals Week **No Class – Work Day**		

PARTICIPATION AND ATTENDANCE

Attendance and participation in this course are both required and will be taken during every lecture. Specifically, at the end of all lectures, there will be a short, reflective written exercise which will serve simultaneously as a tool for collecting attendance, a form of class participation, and an opportunity for you to grow as learners. Other opportunities for course participation will include moments of call and response during lectures, in-class group discussions, and other short activities.

Keep in mind that, in addition to the research suggesting that student attendance contributes to both performance and knowledge acquisition, the instructors will also use course time to disclose necessary changes or information about the course. DO NOT RELY ON THAT INFORMATION BEING CIRCULATED BY WORD OF MOUTH OR HEARSAY CIRCULATED AS FACT AND POLICY..

RESUBMISSION POLICY

In AME4163, teams and individuals will have the opportunity to resubmit graded work, at their discretion. In general, the proper protocol and rules for resubmitting work are as follows:

1. Notify the instructor (and CC the GTAs) of you or your team's intent to resubmit a particular assignment.
2. From the date that graded work is returned to individuals or teams, you will have one week to resubmit. For example, if graded work is handed back on Tuesday during class, you will have until the following Tuesday at midnight to resubmit the assignment.
3. Structure of resubmission:
    a. New self-grading sheets appropriately filled in
    b. Include the old (marked up) self-grading sheets (and identify them as such)
    c. Include a sheet in which you identify what you changed, where these changes are located, and why your grade should be modified. The 'why' is important. In the context of the rubric and the feedback, indicate clearly how the additional information warrants a higher grade.
    d. The revised submission with changes highlighted. Changes can be highlighted either using Word's built-in highlight function or by including document notes/comments.

MACHINE SHOP

As a key component of the course project is the construction of a working prototype capable of addressing the challenges posed, many of you will likely be in unfamiliar territory. An excellent resource available to you are the people who run the AME machine shop, which includes the machine

shop supervisor Billy Mays and machinist Greg Williams, along with several undergraduate assistant staff.

While we encourage each team to take advantage of this resources where needed, we also expect you to be respectful of the time and expectations of the staff. With upwards of forty groups in this course, the machine shop runs the risk of being overrun by students requesting help. Consequently, you are expected to plan your requests for assistance/resources in advance and with careful mindfulness of what your actual needs are. Additionally, please do your best to avoid waiting until the last possible weeks before the project demonstrations; in the past this has caused resources to become unnecessarily tied up.

Both Mr. Mays and Mr. Williams are excellent sources of wisdom regarding the machining and buildability aspects of your prospective concepts. Leverage their advice early in the process and do not wait until the final few weeks to begin building your devices.

III. PROJECT WINDBAG

PROBLEM INTRODUCTION

As was outlined on Page 4 of this booklet, AME4163 revolves around a central semester-long, team-based project. This project is designed to provide students with the opportunity to act as junior engineers exploring solutions to a complex, multi-level, and competency-building problem. One component of that experience is that the problem revolves around a central narrative. This narrative provides the opportunity to diagram the problem within its complete context, just as problems in the real world exist within particular contexts. Further, due to the fact that narratives contain a large amount of information of varying degrees of usefulness to the problem, the junior engineers are expected to determine which of that information is most important, of some importance, and irrelevant. This experiential learning provides the basis on which competencies will be further developed.

PROBLEM DESCRIPTION

Professor Joachin Witherspear is moderately displeased. Although he had originally been excited about being invited to teach at the University of Vayu, (he had been awarded the coveted Bosh nef Storey Fellowship, named after the founder of the University, a man responsible for many innovations on the planet of Vayu) he is rather upset with the arrangements. He has been given a nice office and a brand new compu-station, but the keys for the office and the building will take a week and a half. The Galactic Express people have been very nice in extending him credit, but he is not sure that it will be enough. And then there are all the numbers and forms and who knows what else that he had to apply for just to get the power and tele-vid turned on at his rental house. Still the house is clean, and the people are friendly enough. He is determined, as would be anyone from his planet of Gleesong, to do the best job he can while at the University of Vayu.

“It is a good thing that I am still single, or this move to Vayu would have been extremely difficult,” Joachin thinks to himself as he walks to the conference room for his appointment with a Mr. Vindebagg. “I wonder why the chair-person wants me to meet with this gentleman - my neighbor says he is a crackpot!”

As he enters the conference room, Joachin gets his first look at Thaddeus P. Vindebagg - the new professor. He knows that it is this worthy gentleman because of the outsize badge Vindebagg wears, announcing to all and sundry his moniker. In addition, it proclaims his profession to be that of “Professional Concept Generator and Expeditor”. The badge is only the beginning. Vindebagg is wearing a tunic made of patchwork, silvery corduroy trousers and shoes that have mates but not in this room. Joachin suspects that the socks, if Vindebagg wears socks, match about as well as his shoes. His hair is beyond the ability of any mortal barber to bring under control. But the man's face draws attention away from the scenic tour that is his attire. His eyes are alert and penetrating, and it is almost as if one can see a computer screen behind these eyes, constantly scrolling past new ideas being generated.

“Don’t be put off by the clothes, friend, even though they do make me look a bit crack-potish,” says Vindebagg, echoing Joachin’s first thought.

“Thaddeus P. Vindebagg, at your service. As you can see from my badge, my business is conceptualizing and idea generation, and helping other people do the same. The clothes are to jar people out of complacency and to demonstrate the principle of synthesizing a new artifact from an unlikely set of concepts. But enough of that. I’ve come to discuss developing a concept of my own.”

“My name is Joachin Witherspear, but I am unsure why you would want to speak to me. There are many professors here, senior to me, and with better contacts in industry. I am very much the new kid on the block,” returns Joachin.

“Well, in truth I asked to speak to your chairman. I thought you were a bit young. Now I see what your chairman thinks of me.”

“Wait a minute, I am not without talent or competency. I do hold the Bosh nef Storey Fellowship.”

“Ah, Bosh nef Storey ...”, muses Vindebagg, “there was an engineer with imagination and vision. Not like some of these around today. Well, perhaps you are the best bet after all. Would you like to hear my concept?”

“I am here, so I might as well listen. Please, go ahead.”

His face becoming ever more animated, Vindebagg pulls out diagrams, sketches and scribbled paragraphs from his overstuffed satchel. Spreading them on the conference table, he begins, “You see, it has to do with harnessing the wind...”

“I see why you are having so much trouble with this concept,” interrupts Joachin, “From what I have seen so far, there is very little wind on Vayu, just a pleasant breeze. Besides the sun shines all the time, except for the hour of rain every day, so you can harness the sun for energy. This idea will never sell on Vayu.”

“It is true there is little usable wind on Vayu. This is why it is such a good world for growing food. Very little wind erosion occurs and the weather is mild,” lectures Vindebagg, adding testily, “But I never said that I wanted to ‘sell’ the idea on Vayu. There are other worlds...”

“I’m sorry, please continue.”

“Quite all right. The concept got its start when I was reading some books of history about wind power. Sailing ships and windmills, that sort of thing. But what I thought would be interesting, would be if we were able to able to harness the wind and store it as energy...”

“And then use it later at a site remote from where the wind source is. Of course, I was blocking thoughts before, but now I see what you are getting at,” says Joachin excitedly. “We could use such a device to power vehicles and such on my home planet, Gleesong. (They call it that because the wind blows all the time so that it sounds as if someone is constantly singing. We are a resource poor planet and the weather is mostly cloudy so that solar energy is right out. Presently, we are importing nuclear fuels to provide energy, and even though there is no danger of melt-down in our power plants, we still have a waste disposal problem. The government has begun building windmills to provide power, but no one has thought of using it to power vehicles. We are still using fossil fuels at present!”

“Then we agree, this is a concept that must be pursued, Joachin, but we must have some energetic young people, without preconceptions, to help us.”

“We can get the Design class to take this on as a project, Thaddeus,” says Joachin, adding, “But we need a name, or phrase, to rally around ... hmm ... How about, **Wind B**lown **A**pplications **G**roup - **WindBAG**!”

"Perfect, just perfect," beams Vindebagg. "This is what I call concept generation indeed."

DETAILS AND EVALUATION

Task

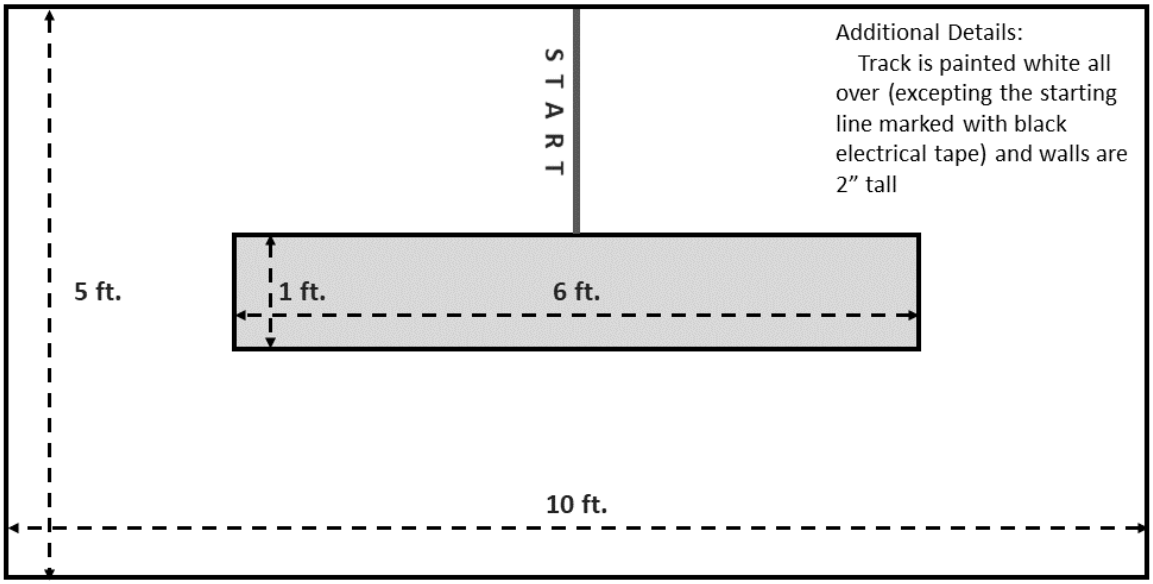
Design, build and test a system capable of converting wind energy into some more useful form of energy and then store this energy in some compact, transportable module. The wind source will be represented by a household electric fan, and the energy modules must be used to propel a vehicle, carrying as large a payload through as many loops around a track (see image below) as possible, subject to the restrictions and conditions.

Restrictions

1. No minimum or maximum number of dimensions is specified, though teams are reminded to be aware of the track dimensions
2. No maximum weight limit is specified
3. A maximum budget of $100.00 is required with a bill of materials for the finished devices to be used to validate the amount spent

Conditions

1. The vehicle will be required to move around the following track:



2. No guide wires of any kind will be allowed. Once the system is placed on the track, any additional touches from a group member will receive a penalty. The vehicle may utilize the walls for navigation but may NOT hang over the top of the walls ('grabbing the edge')
3. From the time the vehicle begins moving until it runs out of usable energy, the number of loops of the track will be counted. Partial loops will be noted and used in the event of a tie.

Performance Tests

The mechanism that is to be tested shall consist of a conversion/storage device, energy modules and a vehicle. In the first part of the test, each group will be given 5 minutes to convert and store as

much energy as their design allows. The energy modules shall then be integrated with the group's vehicle, the payload added, and two runs shall be made.

The performance run will be scored by two measurements. These are:

i. The useful load carried by the vehicle (payload)
    a. This measurement demonstrates the useful work down by the vehicle and energy module
ii. The number of laps traveled by the vehicle
    a. The number of laps traveled by the vehicle will be used in the calculation of points for this portion of the performance test.
    b. Once the vehicle has crossed the start line it shall not be aided in any way to complete traversing the course.

Each system will be required to go through the performance test twice. Teams will be allowed two minutes to set up their system before each run on the course, which includes installation of modules and payload. The system must be removed from the competition area within one minute after completion of the test. Penalties will be levied if the set up and removal times are exceeded.

The points for each part of the performance test will be calculated as follows:

i. Points for payload
    a. $P_1 = \left[\frac{Weight - Weight_{min}}{Weight_{max} - Weight_{min}}\ x\ 50\right]$
    b. Where
        i. *Weight* is the payload
        ii. $Weight_{max}$ is the maximum payload any group's vehicle carries
        iii. $Weight_{\text{min}}$ is the minimum payload any group's vehicle carries (or a suitable minimum selected later)
ii. Points for number of laps travelled
    a. $P_2 = \left[\frac{Laps - Laps_{min}}{Laps_{max} - Laps_{min}}\ x\ 50\right]$
    b. Where
        i. *Laps* is the number of laps travelled by the groups device
        ii. $Laps_{max}$ is the maximum number of laps travelled by any group's vehicle
        iii. $Laps_{min}$ is the minimum number of laps travelled by any group's vehicle (or a suitable minimum selected later)
ii. Original points
    a. OP = P_1 + P_2 – Penalties
    b. The sum of the original points from both runs of the performance test will be the group points. The group with the most points will be judged to be the winners of the competition

IV. COURSE ASSIGNMENTS

AME4163 is divided into several course assignments which comprise the steps of a design process as described on Page 1 and illustrated in the table on Page 7. These assignments are supplemented by lecture materials, in-class and out-of-class exercises, and readings. Here we provide detailed instructions for each assignment and general tips for their completion. Use this document to track your progress and leverage the materials presented here to complete the assignments.

GENERAL TIPS

1. Professionalism

   Never ignore the importance of formatting and professional appearance in a document. They are easy points and serve to make documents more readable and, thus, more engaging. Many miss these or gloss over this formatting and thus lose the points that can very often be the difference between an 'A' and a 'B' or a passing and a failing grade.

2. Understand the Rubric

   Leverage the grading scheme provided for each assignment to complete the task. The grading schemes are not arbitrary and reflect the interests of the instructors. A great deal of time and effort has been put into deciding what to value in each assignment and what categories of evaluation to include; each team should thus prepare each assignment to that articulated standard.

3. Demonstrate Learning

   The most important thing students can do to curry the favor of the instructors is to demonstrate real learning. Note: THIS DOES NOT REFER TO THE ACQUISITION OF TECHNICAL PROFICIENCY. The instructors do not have any interest beyond baseline acknowledgement for acquired skills in SolidWorks or wiring electrical circuits. They want you to learn by reflecting on doing and demonstrate your ability to plan and to identify, perform reality checks in the process of solving complex, open-ended, ill-structured problems like those faced by practicing engineers.

4. Manage Time Effectively

   In every class, every year, inevitably, some groups wait until the last few days to complete not just the assignments but the actual design and construction of their project device. This simply is not doable in a course as immersive and complex as AME4163. To avoid this pitfall, pay close attention to the Team Contract and Plan of Action you propose in Assignment 1. Document up front when people will be away during the semester. Identify how they will "compensate" the rest of the team upon their return. Utilize texting, communication apps, email, cloud-based collaboration software, and anything else one can imagine in order to organize yourselves to beat the deadlines.

5. Ask Questions

   Both the instructors and the GTAs are an excellent resource for course information. Do not hesitate to email or visit them in person during their office hours. Their goal is to help you to be happy in learning and succeed. Your instructors are a resource: utilize them.

ASSIGNMENT 1: PLANNING A DESIGN PROCESS (POED 1A, 1B, 1C, 1D, AND 5B)

Assignment Summary

Identifying the skills and weaknesses of a team will allow it to work better together. Team members that are proficient in a skill can lead a part of the project while another assists them. This will help the assistant to learn a new skill. With all the skills identified, the preliminary work of the project can be divided up so that each member will know what to work on and what to expect. To best complete the project, the team needs to understand the problem. Defining the problem is very important because understanding the problem is crucial to solving it well. Once the problem is defined, the customers need to be identified. The customers will help with filling in the House of Quality and then it will assist with creating the Requirements List. With the customers identified, the customer requirements need to be understood and translated into engineering requirements. The information gathered and created here will assist in the development of the Function Structure and Morphological Chart.

Target Principles of Engineering Design

1a, 1b, 1c, 1d, and 5b

1. Team Skill Inventory

Discuss amongst the team each members' skills which are pertinent to engineering design. Take a thorough inventory of the skills the team brings to bear. Construct a table detailing the relevant skill sets of the members of the team. Utilize the template table to organize these skills into useful categories. Focus on speculation about which team skills will be useful in this project.

2. Team Contract Understanding

A team contract document has been provided to all teams. Read through the document, discuss its points, and form an understanding of how the team can best leverage the procedures laid out there or develop new ones. Answer the questions in the template. Include a statement affirming acceptance of the contract with the signatures of all members.

3. Project Schedule

Create a Gantt Chart detailing the actions that will be required to complete the course project.

This chart should include budgeted time for designing, building, and testing the mechanism.

Craft tasks in terms of the team members as individual task leads (who will be in charge of what portion of the project). This document will be updated and kept throughout the semester.

4. HOQ

Using the releveant course lectures and examples provided, develop a HOQ for the project.

Consider the customer needs and use that to inform the process.

5. Requirements List

Based on the results of the HOQ exercise, develop a Requirements List for the project. Categorize requirements in terms of Demands and Wishes as well as relevant categories (technical requirements, manufacturing requirements, aesthetic, etc.)

Build a list that makes sense given your analysis and unique skillsets.

6. Problem Statement

As a team, discuss the problem in the context the device will function. Develop a statement describing the team understanding of these functions

After completing the HOQ and Req. List (Steps 4 and 5), revisit the earlier problem statement and revise it in terms of the customer Wishes.

7. Take Aways and Learning Statements

For the team, develop one Take Away pertaining to one of the target POEDs for this assignment.

Brainstorm major takeaways from this assignment. Each team member write one take away and thee associated learning statement for each of the target POEDs for this assignment. See table on Page 7.

Note: PLEASE USE THE PROVIDED ASSIGNMENT TEMPLATE, AVAILABLE ON CANVAS

ASSIGNMENT STEP CHECKLIST

Suggested Assignment Length: 17 Pages. Grading rubrics are included in the assignment templates. Review carefully grading rubric; see Page ??. Plan to address items specified in the rubric to minimize your effort and to maximize your grade.

1. Team Skill Inventory and Team Prospectus

Skills, Experience, and Strength of Team

Categorization of the experiences are believable, and they relate to competencies and meta-competencies

a. Teams should use this as an opportunity to analyze their unique experiences and qualifications which may lead to success in the project.

b. One useful way to begin this list may be to leverage the resumes of each member of the team.

   NOTE: This may also be a useful opportunity to update your resume for the upcoming career fair!

c. Brainstorm a large list of skills and assets and then break this list down in to relevant categories.

d. Think critically about the demands of the project to identify relevant skills.

e. Distill the relevant skills into the provided table with useful categories.

f. Be meticulous with this table as it will be used in Assignment 3.

2. Team Contract Understanding

Executing the Team Contract

Exploring how the team intends to use the Team Contract provided to ensure team success.

a. Write out a statement explaining that each member of the team has read and understood the contract and intends to adhere to it in the upcoming project. Further, the statement should indicate that all members have signed a printed copy of the contract.

b. Designate a single person as the team communicator, responsible for submitting assignments and sending out necessary regular emails, text messages, etcetera. In addition, explain what roles all other members of the team will serve.

c. **EACH** team member (identified by name) must write a brief paragraph explaining their take away from the team contract (their responsibilities, understanding, etc.).

**Note: It is advised to begin item 6 at this stage, then complete Items 3, 4, and 5 before finalizing Item 6.*

3. Project Schedule

Team Gantt Chart

All steps in process shown with critical path, important dates from class, description of steps, and extra time accounted for. Gantt chart readable and formatted well for printing.

a. Use available examples to ensure that the chart is readable and clear.

b. Create the Gantt Chart in a form that will be able to be edited throughout the semester.

c. Develop a system or schedule for regularly updating this document.

d. Format to display in the main body. Do NOT include this as an Appendix.

4. House of Quality

HoQ is complete and correct

a. Include all categories laid out in the examples.

b. Use the template provide to ensure completion.

'Whats' and 'Hows' of HoQ are extensive

'Whats' cover multiple customers; Be sure to have 'Hows' for each 'What'

a. Use the text of the project description to inform the 'Hows' and the 'Whats'.

b. Brainstorm for a thorough listing of these aspects.

c. After they have been formed, perform a Reality Check to ensure completeness.

Customer requirements are explained

a. Use an additional section of text to succinctly explain the customer requirements.

b. Justify their inclusion and their relative importance.

c. Write in terms of the customers as real people with real needs.

Engineering requirements and all numbers are justified

Created from customer requirements

a. Use text to justify team choices regarding thresholds for meeting criteria.

b. All criteria should have some numerical target (if applicable) or some tangible metric for success.

Justification and process for determining relative weights for 'Whats' are provided

a. Explain the methods used to choose weights. Examples can include team votes, several HOQ iterations run with random weights, or reasoned deliberate choices.

b. Justify why the results of those choices will enable team success.

Results from HoQ are explained

a. Explain the consequences of the HOQ results.

b. Describe how the HOQ results will affect your design process and choices moving forward.

c. Explore the relation between the HOQ results and the plan of action moving forward.

5. Requirements List

The Requirements List is extensive and detailed for the project

Covers demands and wishes with appropriate information for each and who is responsible

a. The Requirements list, in addition to having each requirement labelled a want or a demand, should also be broken up into various categories. Choose relevant categories. Examples include: technical requirements, safety requirements, manufacturing requirements, device performance requirements, etc.

b. This list should be thorough, and each requirement should have some target or measurable objective for success. Numerical objectives are most common (e.g., "Our device must weigh less than X lbs.") but qualitative objectives can be used for relevant requirements (e.g. "Aesthetic Requirements – Device must be painted red and blue").

The Requirements List has correspondence with the HoQ

a. The results of the HOQ can be added directly to the Requirements list but should not be the only items listed.

b. Other requirements must serve as expansions on the HOQ results.

6. Problem Statement

Problem Statement before HOQ and Requirements List
Create initial problem statement from a purely technical standpoint

a. Think about the problem overall as a device to be built. This version of the problem statement should be heavily focused on the technical.

b. Think about the specific functionality required of the device. Think in terms of technical feasibility.

Revised Problem Statement
Create with new knowledge and insight

a. Given the results of the HOQ and Requirements List, think about new information that is relevant to the team understanding of the problem.

b. Leverage the priorities created in the HOQ to define the problem around the most important customer requirements. Create a team understanding of what the primary problem needing to be addressed is, followed by secondary objectives, tertiary objectives, and so forth.

c. Define the problem around the specific, measurable, achievable objectives defined in the Requirements list.

d. Modify the initial problem statement with your updated understanding of the problem.

7. Take Aways and Learning Statements

Draft team and individual learning statements
Competencies, insight, etc.

a. Learning statements must be a triple, with key words underlined and a single sentence. Show relation to POED.

b. Develop learning statements focusing on the following Principles of Engineering Design: 1a, 1b, 1c, 1d, and 5b (See Page 1).
c. Individual: Identify at least one Take Away associated with each targeted POED for this assignment. Write a Learning Statement associated with each Take Away. Each team member is required to submit 5 Take Aways and 5 Learning Statements.
d. Team: Choose a single target POED for the team and write a Team Take Away for it. You may submit Team Take Aways for multiple POEDs. Be sure to relate Take Away to POED. No Learning Statement is required.
e. For individual learning statements remember this course is about getting you to internalize the principles of engineering design. Think and write so that you have generated sufficiently insightful lessons learned that can be leveraged in the Semester Learning Essay (Assignment 6).
f. Include full names for each student in the spaces provided in the provided assignment template.

8. Professionalism

Professionalism – Bonus

a. Team number (not Team Name), names of members, page number in footer
b. Question written out then answered
c. Reality checks
d. Clarity, connectivity, utility
e. Spark, insight, extra effort

Comments

Though professionalism is, for this assignment, left as a bonus, in future assignments it will be a requirement. Be sure to get into the habit of preparing formal reports in well-established and easily-readable formats.

ASSIGNMENT 1 TIPS

1. Ensure that you put together a strong Team Contract that has buy-in from ALL team members. Document up front who may be away when and how this person will make up for the lost time.

2. Plan to critically evaluate each other critically and make appropriate changes to the Team Contract and mode of operation.

3. Ensure that in the HoQ you include the requirements of three “customers”, namely, the citizens of Vayu, the need for you to internalize the POEDs and hit the road running as Junior Engineers, the course requirements outlined by the instructors.

4. Ensure that in the HoQ you include the requirements of three “customers”, namely, the citizens of Vayu, the need for you to internalize the POEDs and hit the road running as Junior Engineers, the course requirements outlined by the instructors.

5. Foundational to the Requirements List (Demands and Wishes) is the HoQ. A good HoQ is needed to come up with a good Requirements List. Do not include preconceived notions that you undoubtedly have into the Requirements List.

6. Make sure that the requirements for each subsystem of the robot is covered.

7. Assignment 1 is foundational to the assignments that follow in AME4163 and is repeated as Assignment 7 – Planning for your project in AME4553. Invest the time and deep thinking to get this right.
8. Reality checks
    a. Three customers identified and used in the HoQ analysiss?
    b. Requirements List includes Demands and Wishes associated with three customers?
    c. Buy in for Team Contract from ALL team members? This is key for a happy experience in AME4163.
    d. Satisfied that you can build on Assignment 1 in Assignment 2? Justify.
    e. Completed the self-grading sheet with justifications related to rubrics?
9. Before uploading the assignment check that you have put together against the grading scheme. Fix if necessary.

ASSIGNMENT 1 PAGE BREAKDOWN

Item	Section	Suggested Pages
0	Self-grading + Rubric. See Page ??	NA
1	Team Skill Inventory and Team Prospectus	5
2	Team Contract Understanding	1
3	Problem Statement	1
4	Project Schedule	2
5	House of Quality	5
6	Requirements List	2
7	Take Aways and Learning Statements	1
8	Professionalism	NA
9	Appendix Team Contract	NA
	NOMINAL TOTAL	17

AME4163 SAMPLE TEAM CONTRACT

Preamble

The following is a draft team contract for your team's consideration. A copy will be made available as a downloadable document on Canvas. This document is designed to be a tool for all teams. All members should read thoroughly, discuss, make needed changes, and sign it before implementing. Use this as a tool to help resolve conflict, promote organization within the team, and improve efficiency of labor within the team. Make an effort within the context of the overall project to utilize the various aspects of the team contract to improve your work. It is highly encouraged that all team members read through the team contract and sign in the appointed space at the end of the contract.

Team XXXX – Team Contract

Date: MM/DD/YY

1. **Team Coordinator**
    a. YYYY will serve as the Team Coordinator. He/she has agreed to fulfill the following responsibilities:
        i. Task delegation for the entire team taking input from the team members into account and ensuring an equitable distribution of workload.
        ii. Communicating all essential information to the team in an orderly, prompt fashion via emails or text messages/group messages.
        iii. Calling meetings and deciding on meeting times.
        iv. **All work** will be submitted by the Team Coordinator unless otherwise defined by the assignment parameters including:
            1. Completed assignment submissions in Word/PDF format
            2. Team Learning Statements (Individual statements will be submitted by each member of the team)
        v. Team Coordinator may delegate responsibilities for coordinating the team when appropriate.
    b. ZZZZ has agreed to serve as the back-up Team Coordinator and will fulfill the role of the Team Coordinator when appropriate.
    c. The Team Coordinator (and back-up) can be removed upon the request of the majority of team members, subject to the approval of the OU mentors for this project, from that position if and only if the Team Coordinator exhibits poor leadership, breaches the team contract, or is otherwise deemed unfit to coordinate
2. **Code of Conduct**
    a. As a team, we will:
        i. Not tolerate disrespect towards other team members on the basis of religion, ethnicity, gender, or sexual orientation. Such disrespect is grounds for OU mentor involvement and/or removal from the group.
        ii. Hold each other to high standards and be aware that anything less than 100 percent effort on assignments affects the entire team's performance.
        iii. Set/agree to standards of quality.
        iv. Respect the time of our peers. We understand that our individual time is not worth more than anyone else's.
        v. Appear on time for meetings.

        The decisions of the Team Coordinator should be made with the entire team in mind with the main goal being team success.
3. **Conflict Resolution**
    a. As a team, we will:
        i. First attempt to deal with all issues that may arise **internally**. OU mentors will only become involved if no resolution can be reached amongst ourselves.
        ii. Seek to understand the interests and desires to each party involved before arriving at answers or solutions.
        iii. Choose an appropriate time and place to discuss and explore the conflict.
        iv. Listen openly to other points of view.
        v. Acknowledge valid points that the other person has made.

vi. State our points of view and our interests in a non-judgmental and non-attacking manner.
vii. Seek to find some common ground for agreement.
viii. Acknowledge that because of the team-oriented nature of this project, potential situations may arise where the thoughts and ideas of one team member may be passed over (even after deliberation) for the benefit of the group as a whole.
ix. Proceed to implement the team decision upon resolution of the conflict.

4. Accommodation Standards

a. As a team, we acknowledge:
   i. That there may be more than one correct/acceptable approach to arrive at an answer to a problem. Accordingly, we will be open to accommodating all reasonable / practical points of view.
   ii. That we are all individuals and we all think about things differently.
   iii. That in order to excel, it would be prudent to allow the learning/engineering styles of each member to work together in a positive way instead of letting them interfere with one another.
   iv. The importance of proceeding through consensus. In the event that there is no consensus the majority vote will prevail and all will get behind the decision made by the majority.

5. Communication Standards

a. In Meetings:
   i. All ideas will be listed to and taken into consideration.
   ii. The goals of the meeting will be discussed and displayed at the beginning of the meeting, and will be checked off as completed. To eliminate misunderstandings action items (who is to do what) will be covered at the end of the meeting.
   iii. Productivity and efficiency are essential.
   iv. Meetings will only be held when necessary.
   v. The cancellation of regularly scheduled meetings is solely at the discretion of the Team Coordinator.
   vi. Additional meetings may be called as deemed necessary by the Team Coordinator in consultation with the team members.

b. Outside of Meetings:
   i. We recognize the importance of reading and responding to all text messages and emails.
   ii. Responses to emails/text messages must be sent in a reasonable amount of time.
   iii. “Reasonable amount of time” is defined as 6 hours for text messages and 12 hours for emails.
   iv. If a team member is unable to attend a meeting, the Team Coordinator must be notified at least 24 hours in advance. This clause can be ignored in extreme or emergency situations (examples include issues of health or family need).
   v. Restrict SMS communication between team members between 10:00PM and 8:00AM excluding dire emergencies.

c. Peer Reviews
    i. We will participate in a biweekly “peer review” process, separate from the coursework required, to ensure accountability and quality standards are being met by every member of the group.
    ii. These peer reviews will NOT be anonymous and will be shared amongst the team members.
    iii. The Peer Review Form (for Peer Review Form, see Appendix A) will be completed and turned in at the end of that week’s meeting.
    iv. It is expected that these peer reviews should be taken seriously. Each member will reflect on the feedback and take appropriate action to ensure the success of Team XXXX.

6. Team Meeting Standards

a. Meeting Frequency
    i. Meetings will be scheduled twice a week. Assuming the tasks are completed in the first weekly meeting, the second weekly meeting (for that week) will be canceled.
    ii. Agendas will be discussed at the beginning of every meeting and will be prepared by the Team Coordinator with input from team members.
    iii. The expectations for future meetings will be discussed at the end of each meeting to allow for transparency for all group members about what is expected.
b. Meeting Leadership
    i. Meetings will be called by the Team Coordinator, or her/his designate as situations apply.
c. Meeting Organization
    i. The team will be incorporating a SCRUM Board for organization purposes.

7. Quality of Work

a. As a team:
    i. We expect all work done by every member to be quality work as agreed to by the team.
    ii. We expect all work done by every member to be done on time.
    iii. We acknowledge some weeks will be busier than others; this is NOT an excuse to provide work that is not up to the quality standard OR pass work onto other team members.
    iv. Any time a team member knows that he or she would be unable to complete an assignment either on time or up to the quality standard, the Team Coordinator must be notified at least **48 hours** in advance in order to allow for the assignment to be completed. (This provision is for health-related emergencies only.)
    v. We acknowledge that if a member(s) of the group consistently produces sub-par work that is either late or does not fit the quality standard, the OU mentors will be notified and this is grounds for removal from the group.
b. All assignments are due to the Team Coordinator at **LEAST** 24 hours before the official due date in order to accommodate revisions if necessary.

c. Work that is not up to the quality standards (i.e., did not follow instructions, was poorly done, was unfinished etc.) will be returned to the original author for revision.
d. The revisions mentioned above will be delegated by the Team Coordinator and any or all of the other members of the team (assuming all involved with the revisions has read and understands the submission).

8. Consequences of Contract Breach

a. As a team:
   i. We will always first address the issue internally. If no resolution is reached, then OU mentors may be involved.
   ii. We acknowledge that a breach of the contract can result in OU mentor involvement and potentially the removal of that group member from the group
   iii. We acknowledge all grade penalties/repercussions associated with removal from the group.
   iv. We acknowledge the importance of peer reviews in this course. We are aware that we will receive honest and fair reviews from all members of the group that accurately reflect our performance.

9. **Member Names and Signatures**

I understand the contents of this document and agree to abide by it.

Signed (with date) 1

Signed (with date) 2

Signed (with date) 3

Signed (with date) 4

Appendix A for Team Contract

Peer Review

Review each team member on his or her performance during the past two-week period. Please be honest and fair, as these reviews will be referenced during end-of-semester peer review. Please turn into the team leader when completed.

-1 Said person is contributing one or more letter grades below the team average.
-1/2 Said person is contributing one-half letter grade below the team average.
0 Said person is contributing at the same level as the other team members.
+1/2 Said person is contributing one-half letter grade above the team average.
+1 Said person is contributing one or more letter grades above the team average.

	Contributes to workload, Carries their fair share.	**Actively participates in & contributes to meetings and activities**	**Delivers on commitments, does what they say they will do**	**Exhibits professional and ethical behavior on all aspects of assignments**
Name 1				
Name 2				
Name 3				
Name 4				
Name 5				

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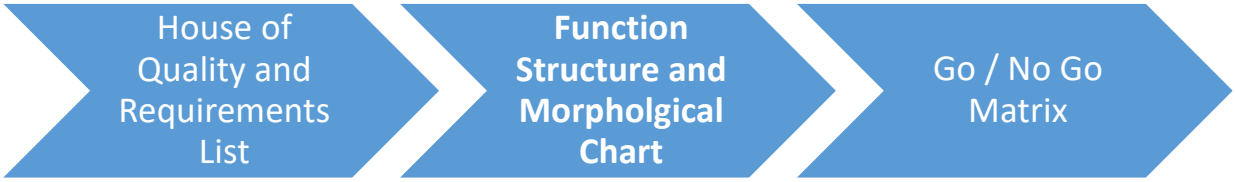
	Contributes to workload, Carries their fair share.	**Actively participates in & contributes to meetings and activities**	**Delivers on commitments, does what they say they will do**	**Exhibits professional and ethical behavior on all aspects of assignments**
Name 1				
Name 2				
Name 3				
Name 4				
Name 5				

ASSIGNMENT 2: PRELIMINARY DESIGN (POED 1D, 2A, 2B, 2C, AND 5B)



Assignment Summary

The Requirements List that was created in the previous assignment will be used to do reality checks on the Function Structure and the generated concepts. The Function Structure provides a visual representation of all the sub-functions that the device will need to accomplish in order to complete its tasks. The sub-functions will then be used with a Morphological Chart to ideate different options that are viable to complete each sub-function. Once the chart has been completed it will be used to generate possible concepts. The Morphological Chart is a great tool to identify possible combinations that may have not been initially thought of. The generated concepts will then be evaluated in a Go/No-Go Matrix using the Requirements List as the evaluation criteria.

Target Principles of Engineering Design

1d, 2a, 2b, 2c, and 5b

1. Function Structure

Outline the functions of the completed device and divide into sub-functions.

Describe functions in terms of how material, energy, and information flow through the process.

Construct a diagram which traces these sub-functions throughout the system.

2. Reality Check

Using the Requirements list, ensure that the sub-functions identified meet the target performance requirements.

Check the logic and order of the functions to identify possible corrections.

3. Morphological Chart

The sub-functions in the Function Structure diagrram will be used to generate the Morphological Chart.

Each sub-function will become a row in the Morphological Chart.

For each row, list several specific ways to accomplish each sub-function and describe each in detail.

4. Concept Generation

Go through the Morphological Chart six times from top to bottom, selecting one of the specific methods for each subfunction. Each complete run-through becomes a distinct concept. In total, each team should generate 6 complete system concepts.

5. Plus, Minus, Interesting

For each concept, create a list outlining the plusses, minuses, and most interesting points for each concept.

Be sure to look at sub-function mechanisms to determine advantages and disadvantages of the various configurations.

6. Take Aways and Learning Statements

For the team, develop one Take Away pertaining to one of the target POEDs for this assignment.

Brainstorm major takeaways from this assignment. Each team member write one take away and thee associated learning statement for each of the target POEDs for this assignment. See table on Page 7..

Note: PLEASE USE THE PROVIDED ASSIGNMENT TEMPLATE, AVAILABLE ON CANVAS

ASSIGNMENT STEP CHECKLIST

Suggested Assignment Length: 25 Pages. Grading rubrics are included in the assignment templates.

1. Function Structure

Appropriate flow of materials, energy, and signal (information) that are anchored in the functional requirements identified in the Requirements List (Assignment 1)

Completes task in a logical manner

a. Do a reality check. Explain why this particular Function Structure, if implemented, is feasible.
b. For all sub-functions, use noun-verb tuples to describe the sub-function.
c. Matter, energy, and information INTERACT with each other for WindBAG to be functional.
d. Be sure that someone tracing the flow of matter, information, and energy throughout the system could understand every step needed to accomplish the required task.

Notes on Function Structure

a. Explain the relationship between the Function Structure and the Requirements List (Assignment 1). Do a Reality Check. You may have to modify the Requirements List.
b. Explain the role of matter, energy, and information in the function structure and how they interact.
c. For connectivity, refer to the function structure figure and then do the writing.
d. For connectivity indicate what question you are answering AND provide a figure number and title for the figure.
e. Explain each function as a verb-noun tuple.
f. A Function Structure MUST have a boundary with something going in and something coming out.

2. Reality Checks. Include in writing in Assignment 2

Inputs shown with appropriate connections to complete the task

a. Are all the functions documented in the Requirements List mapped into the Function Structure?
b. Have you specified a Boundary for the Function Structure?
c. Materials, energy, and information is input to the boundary. There MUST be something that comes OUT of the boundary at the other end. Has this been shown?
d. The function structure is foundational to ensuring functional feasibility of the device. If the Function Structure is not right, then an appropriate reality check has not been performed. Have you commented on the relationship between the Requirements List and Function Structure. Why are you satisfied and willing to continue?

3. Morphological Chart

Morphological Chart is present and has the proper details

Indicate the question that is being answered.

a. Introduce the Morphological Chart – tie it to the Function Structure diagram.
b. Provide a figure number with a title for the chart.
c. For each sub-function possibility outlined in the chart, provide a short description.

4. Concept Generation

The Morphological Chart is used to generate six feasible system concepts that are FUNCTIONALLY viable and well-thought-out.

a. Refer to the Morphological Chart. Indicate how you used the Morphological Chart to generate six concepts. The method you used MUST be documented in Assignment 2.
b. Give a unique identifying name to each of the six system concepts.

c. Indicate which elements from the Morphological Chart are embodied in each concept. Either provide a table or include this information together with the sketch.
d. Perform a reality check. Include in writing the rationale for continuing to the next step.

Description of each concept's sub-functions and how they work

a. For each verb-noun tuple explain input, function, and output.
b. Do not write an essay in this section; keep it succinct.
c. For connectivity refer to the Function Structure figure.
d. Please augment the descriptions for Assignment 3.

Description for system concepts are provided *Including sketches and how it works.*
Sketches should be clear and presentable

a. Draw sketches BY HAND and label the key features/components. These must be readable. Computer sketches are acceptable.
b. Relate labels to both verb-noun tuple and morphological chart. Leverage from examples shown in lecture,
c. Reality check for FUNCTIONAL feasibility. Why is each concept functionally feasible?
d. Reality check for concept sketch: Is it clear how the concepts tie to the Morphological Chart, to the Function Structure and the Requirements List?

5. Plus, Minus, Interesting

PMI – Advantages, disadvantages, and interesting features for system concepts are provided

a. Include a PMI analysis of the concept description provided. Include the PMI at the end of each individual concept description. In other words, keep each PMI with the concept it applies to, rather than grouping them all together – away from the concepts.
b. Build on the reality check done during the concept description section with the PMI.
c. PMI should be in bullet form. You have the information to evaluate functional feasibility. This is a good time to start thinking about TECHNICAL feasibility based on the available assets; see Assignment 3. Identify what additional information will be needed for the GO/NO-GO decision in Assignment 3.
d. Reality check: Why is what I have provided adequate to build on in Assignment 3? Please include an answer to this question in Assignment 2?

6. Take Aways and Learning Statements

Draft team and individual learning statements

a. Learning statements must be a triple, with key words underlined and a single sentence. Show relation to POED.
b. Develop learning statements focusing on the following Principles of Engineering Design: 1d, 2a, 2b, 2c, and 5b (See Page 1).
c. Individual: Identify at least one Take Away associated with each targeted POED for this assignment. Write a Learning Statement associated with each Take Away. Each team member is required to submit 5 Take Aways and 5 Learning Statements.
d. Team: Choose a single target POED for the team and write a Team Take Away for it. You may submit Team Take Aways for multiple POEDs. Be sure to relate Take Away to POED. No Learning Statement is required.
e. For individual learning statements remember this course is about getting you to internalize the principles of engineering design. Think and write so that you have generated sufficiently insightful lessons learned that can be leveraged in the Semester Learning Essay (Assignment 6).
f. Include full names for each student in the spaces provided in the provided assignment template.

7. Professionalism

a. Team name, names of members, page number in footer

b. Question written out then answered
c. Reality checks
d. Clarity, Connectivity, Utility
e. Spark, Insight, Extra Effort

ASSIGNMENT 2 TIPS

1. Read the assignment very carefully and take note of what is required.
2. Take a careful look at the Grading Scheme to figure out what is required of you before starting work on the assignment; see Page ????.
3. Provide context for what you write by reproducing the task or question that you have been asked to address. Follow this up with your answer. Check that you have indeed provided the information that you have been requested to provide.
4. Reality checks
    a. Function Structure in context of Requirements List?
    b. Morphological chart related to Function Structure?
    c. Concept related to Morphological Chart + Function Structure + Requirements List?
    d. Is PMI analysis for each concept after the description of the concept?
    e. Is each concept Functionally Feasible? Justify.
    f. What do you need to do to ensure TECHNICAL feasibility that is needed for Assignment 3?
    g. Completed the self-grading sheet with justifications related to rubrics?
5. Before uploading the assignment check that you have put together against the grading scheme. Fix if necessary.

ASSIGNMENT 2 PAGE BREAKDOWN

Item	Section	Suggested Pages
0	Self-grading + Rubric. See Page ??	NA
1	Function Structure	2
2	Reality Check	1
3	Morphological Chart	8
4	Concept Description including PMI analysis	12
5	Take Aways and Learning Statements	1
6	Professionalism	NA
	NOMINAL TOTAL	25

ASSIGNMENT 3: EMBODIMENT DESIGN (POED 1D, 3A, 3B, AND 5B)

Assignment Summary

The developed concepts that were generated using the Morphological Chart will be analyzed against criteria from the engineering requirements that were created in the Requirements Lists. The Go / No Go matrix will be used to determine if the concepts are feasible or not. When developing criteria for the matrix, consider both the team skill inventory (A1) and the available assets list compiled here. Think about the design in those terms: what is available and feasible, given existing knowledge. It can also be seen where concepts may succeed while others fail which can allow for merging of concepts to create a better concept. From here the concepts will be narrowed down to a main concept and a backup that will then be generated using CAD.

Target Principles of Engineering Design

1d, 3a, 3b, and 5b

1. Competencies and Available Resources

Develop a list of material assets and useful competencies. These items should include those likely to help in construction and prototyping.

Focusing on tools and assets likely to be useful in building your device, construct a table detailing the items in the above list as well as their location, availability, and/or cost.

2. Establish Evaluation Criteria

Identify and describe 10-15 criteria that will be used in the Go/No Go analysis. This should leverage both the Requirements List and insights gleaned from the concept generation phase

Construct a table to describe these criteria and justify their inclusion. Perform a reality check on the criteria to identify anything missing.

3. Critical Evaluation of Concepts

Include a sketch and brief description of each concept.

Use these items to explore areas of success and failure for each concept.

Do not just focus on failure on a technical level; consider how a complex concept may not be feasible in the available time, for example. Consider all the ways a concept could fail.

4. Go/ No Go Analysis

Create a table with the evaluation criteria and the concepts.

For each concept, at every row of the evaluation criteria put a 'Go' in the cell if the concept meets the criteria and a 'No Go' if it does not.

In text below the chart, justify your Go/No Go decisions.

5. Reduce the Number of Concepts

Using your Go/No Go results, rank your concepts in order of their likelihood to succeed.

Select the top two concepts, perform PMI, and explore their probable failure modes.

Explain how these failure modes can be prevented or minimized.

Justify your primary and secondary concept.

6. Take Aways and Learning Statements

For the team, develop one Take Away pertaining to one of the target POEDs for this assignment.

Brainstorm major takeaways from this assignment. Each team member write one take away and thee associated learning statement for each of the target POEDs for this assignment. See table on Page 7...

Note: PLEASE USE THE PROVIDED ASSIGNMENT TEMPLATE, AVAILABLE ON CANVAS

ASSIGNMENT STEP CHECKLIST

You will be building on Assignment 2. For Assignment 2 you generated six concepts that are FUNCTIONALLY feasible. In Assignment 3 you will be identifying two concepts that are functionally and TECHNICALLY feasible. Through the creation of the Bill of Materials you will touch upon the BUILDABILITY of the concept in Assignment 3. Nominal length: 35 pages. Grading rubric see Page ??

1. Competencies and Available Assets

List and justify the available assets of the team – items that are in your possession or readily available to you (borrow from a friend). The asset list includes not only the tools and materials available that are in your possession OR readily available to you but also the skills, knowledge, and workspaces the team possesses or has access to. Refer to Item 1 from Assignment 1. Focus on those assets and skills which are likely to be useful for building the device (Assignment 2). Do not include an asset or skill that is not likely to be used in building the device. At the end of Assignment 3 you are requested to include a Bill of Materials. The list of Available Assets will morph into the PRELIMINARY Bill of Materials at the end of Assignment 3.

a. Assets are categorized in useful terms such as their relation to sub-systems of the device, budget, or as materials versus tools. Further, use a tabular format and provide sources when appropriate.

b. Where appropriate, note possible limitations or obstacles to utilization of particular assets. For example, "I have a soldering gun, but no one on our team knows how to use it properly."

c. Summary of the available assets must be tied to the Morphological Chart (Assignment 2). This list of available assets will be used to generate the evaluation criteria in Step 2. Note: You are NOT looking for the fastest device. You are looking to build a device that can complete the track twice, that is, functionally and technically feasible, is buildable (by you).

2. Establish Evaluation Criteria

All Criteria for Go/No Go is described

Includes available assets

a. Use the list of available assets to inform the evaluation criteria. At this stage, teams are not just evaluating concepts based on the technical or functional feasibility of the concept but also on whether or not the concept is realizable given the team skills and assets. Individual evaluation criteria should take into account whether the team, given its available assets, has the time, knowledge, or ready-access to materials needed to actualize the concept.

b. Remember to think about buildability, reliability, and maintainability (your ability to make repairs should something go wrong).

c. Use the provided table in the template to outline and describe each individual criterion.

d. Keep your justification of each evaluation criterion limited to a succinct description.

e. Each GO/NO-GO criterion should have a threshold (ideally quantifiable) that enables it to be given a Yes/No decision. Be sure to use the specified threshold values in evaluating the alternatives and document your analysis in Assignment 3.

The list of criteria is between ten and fifteen items long

a. List includes Demands and Wishes (Requirements List in Assignment 1) that are developed from customer requirements and covers all aspects of the device.
b. Make sure your evaluation criteria are tied to your available assets, your technical requirements, concept feasibility and buildability.
c. List of evaluation criteria must be separated into Demands and Wishes, if relevant.

3. Critical Evaluation of Concepts. Update sketches and descriptions of concepts from Assignment 2.
Sketch of concept with all components identified

a. Ensure connectivity between concept, morphological chart, function structure and requirements list.
b. Concepts are generated by the team NOT individuals; provide the same level of detail for each.
c. If hand drawn to ensure readability, sketch with pencil and then use a dark pen over the finished sketch to make the drawn lines clearer.
d. Briefly describe each concept and critically evaluate it. Update what you provided in Assignment 2.
    i. Include an expanded PMI and critical evaluation after describing how the concept works. PMI should include Functional Feasibility, Technical Feasibility, Buildability (in context of Available Assets; see Step 1)
    ii. Comment on the probable modes of failure for each concept and how these could be addressed under competition conditions.

4. Go/No Go Matrix

The Go/No Go Matrix has been properly created
Labeled correctly with colors used to easily show Go or No Go. For readability use white text.

a. In the created matrix, the evaluation criteria make up the left-hand column and the individual concepts make up the top-row.
b. Use colors to highlight cells based on “Go” or “No Go” decisions (Convention is that “Go” is green and “No Go” is red). Ensure contrast between the letters and background so its readable.
c. Evaluation criteria labels in the actual table cells should be succinct enough to fit in one or two lines of a cell. Do not cram large amounts of text into the table; you can provide additional information in text after the fact.
d. Give your table a table number and title.

Explanations for all decisions for Go/No Go have been provided

a. Succinctly justify all decisions made in the Go/No-Go matrix. One way to do this in an organized fashion is to create a new table for each concept with the evaluation criteria in the left-hand column, the concept name at the top of the second column with the Go/No-Go decisions below (in the same column), and then use a third column to list justifications.

b. Alternatively, bulleted/numbered lists can be used. The choice is yours, but the justifications should not be a large paragraph of text.

5. Reduce the Number of Concepts

Six concepts are narrowed to two.

a. In the context of the GO/NOGO matrix outcomes, the expanded PMIs and probable failure modes justify (in writing) the selection of two concepts for further analysis. Just referring to the tables is NOT enough. Justifications must be anchored in the data embodied in the tables.

b. Think critically about the weak points of the concept; even if a concept is a "Go" in all evaluation criteria, attempt to intuit what could go wrong. In particular, given the available assets and skills of the team, consider buildability. Will the built concept be able to complete two runs under competition conditions?

c. Use the expanded PMI to determine ways to improve or combine elements from different concepts. Note, this should not require a totally new concept. It should simply allow you to make intelligent and selective changes.

Reduced number of concepts and explanations have been provided

Show evidence that the available assets have been used to make decisions

a. Recommendations for the reduced concepts should be anchored in the data Go/No GO matrix decisions and the Morphological Chart.

b. Justify the team's decision to elevate one concept to the primary concept and relegate another to backup status. This decision should be predicated on things such as how long each might take to build, the potential cost of each, how likely the concept is to meet all project objectives given team assets and skillsets.

c. Prepare and include a preliminary Bill of Materials for the two selected concepts. In the context of the inventoried assets, known skills and Bill of Materials specify a way forward for building the devise. What issues need to be resolved as you proceed to order material and build the device?

6. Take Aways and Learning Statements

By now you should have gotten the hang of how to do this. If not we urge peer to peer teaching.

a. Learning statements must be a triple, with key words underlined and a single sentence. Show relation to POED.
b. Develop learning statements focusing on the following Principles of Engineering Design: 4a, 4b, 4c, 5a and 5c (See Page 1).
c. Individual: Identify at least one Take Away associated with each targeted POED for this assignment. Write a Learning Statement associated with each Take Away. Each team member is required to submit 5 Take Aways and 5 Learning Statements.
d. Team: Choose a single target POED for the team and write a Team Take Away for it. You may submit Team Take Aways for multiple POEDs. Be sure to relate Take Away to POED. No Learning Statement is required.
e. For individual learning statements remember this course is about getting you to internalize the principles of engineering design. Think and write so that you have generated sufficiently insightful lessons learned that can be leveraged in the Semester Learning Essay (Assignment 6)

f. Include full names for each student in the spaces provided in the provided assignment template.

7. Professionalism

a. Team name, names of members, page number in footer
b. Question written out then answered
c. Reality checks
d. Clarity, Connectivity, Utility
e. Spark, Insight, Extra Effort

ASSIGNMENT 3 TIPS

1. Read the assignment very carefully and take note of what is required.
2. Take a careful look at the Grading Scheme to figure out what is required of you.
3. Provide context for what you write by reproducing the task or question that you have been asked to address. Follow this up with your answer.
4. Check that you have indeed provided the information that you have been requested to provide.
5. Reality checks
    a. Concept related to Morphological Chart + Function Structure + Requirements List?
    b. Is expanded PMI analysis for each concept after the description of the concept?
    c. Is each concept Functionally, Technically Feasible and Buildable? Justify.
    d. Justification of the two selected concepts: Have you justified your choice by including data from the expanded PMI, the Go/NoGo analysis, the possible modes of failure, etc.?
    e. Completed the self-grading sheet with justifications related to rubrics?
6. Before uploading the assignment check that you have put together against the grading scheme. Fix if necessary.

ASSIGNMENT 3 PAGE BREAKDOWN

Item	Section	Suggested Pages
0	Self-grading + Rubric. See Page ??	NA
1	Available Assets	8
2	Concepts + Critical Evaluation	10
3	Establish Evaluation Criteria	2
4	Go/No-Go Analysis	12
5	Reduce the Number of Concepts, critical analysis, justification	2
6	Preliminary Bill of Materials for two concepts	1
7	Take Aways and Learning Statements	1
8	Professionalism	NA

	NOMINAL TOTAL	36

ASSIGNMENT 4: DETAILED DESIGN (POED 1D, 3A, 3B, 3C, AND 5B)

Assignment Summary

In this assignment, teams are tasked with taking the concept selected in A3 and developing that concept using solid modelling software. Using CAD software to build on a selected concept is an important pre-prototyping phase as it allows teams to make specific selections about the design geometry and the arrangement of components. This stage can serve as an important reality check on the feasibility of selected concepts.

Further, in this assignment teams will begin to outline their plans for constructing a device prototype, which will be demonstrated during the project competition. Teams must develop a preliminary Bill of Materials in order to begin categorically planning this construction phase.

Target Principles of Engineering Design

1d, 3a, 3b, 3c, and 5b

1. Refined Concept Description

Reintroduce the concept selected with a sketch and a short description of the key functionality of the concept.

If changes to the concept have been made since A3, describe those changes and justify them.

2. CAD Models

Use a CAD software program to develop solid models for all functional components in the concept. Additionally, use these models to form assemblies, including an assembly of all components. When possible, specify materials and colors so as to make the final assembly clearer.

3. Bill of Materials

Generate a preliminary Bill of Materials, citing specific items the team intends to use to build the device.

Try to focus heavily on the team's available assets and keep in mind the team's manufacturing abilities.

4. FEA of Critical Components

Select four specific components of the finished CAD model and briefly discuss their function in the overall system and probable failure modes.

Perform FEA on each of the four components. Identify boundary conditions, justify inputs, and interpret the results.

5. Learning Statements

For the team, develop one learning statement pertaining to one of the target POEDs for this assignment.

For each team member, brainstorm major takeaways from this assignment and develop one learning statement for each of the target POEDs for this assignment.

6. Appendix

In an appendix section, include engineering drawings of all parts and assemblies created during modeling.

Be sure to include in each drawing a title block with scale, date, team name, part name, etc.

Note: PLEASE USE THE PROVIDED ASSIGNMENT TEMPLATE, AVAILABLE ON CANVAS

ASSIGNMENT STEP CHECKLIST

Suggested Assignment Length: 25 pages. Grading rubrics are included in the assignment templates and on Page ??

If the team is comfortable with the primary concept selected from Assignment 4 then use it for this assignment. If the team isn't comfortable with the main concept look at the backup and proceed with that one instead. Alternatively, teams may elect to merge concepts, provided they elaborate on their justification for doing so.

1. Refined Concept Description

Refined description of concept

Update description and information of the concept from Morphological Chart assignment to include analysis, knowledge, or insight obtained between Assignments 3 and 4.

a. Consider modifications made to the concept since Assignment 3, even slight ones. Explain the reasoning for those changes. It is fine if these modifications did not flow directly from the design process steps of the assignments, but the reason for the changes must be justified.

b. Consider the results of the Go/No-Go which led to the selection of this concept; think about how those results can be used not just to select the most-likely to succeed concept but also to further refine it.

2. CAD Models

Screen dump of CAD models

Assembled, exploded, and others as appropriate also identify the components and provide explanations as needed.

a. Use the mindset that another engineer will try to understand your concept in depth from looking at these screen dumps and descriptions.

b. Use clear views of the CAD models (isometric, profile, etc.) to demonstrate key aspects of the design.

c. If the device involves some mechanism, consider using two or more pictures side-by-side to show the deployed and un-deployed mechanism.

3. Bill of Materials

Bill of Materials is tied to the Available Assets list produced in Assignment 3. This includes (but is not limited to) space to build, tools, competencies/skills of team members, and available materials.

a. Develop a Bill of Materials for the planned construction of the device in terms of each specific component, number of each component (for components which repeat), and category of item.

b. At this phase, focus on leveraging as much as possible from the list of available team assets developed in Assignment 3.

c. Focus on buildability and pragmatism; many groups at this stage want to go buy expensive components or fabricate relatively simple components when plenty of existing parts are available to them already. Keep it simple and practical.

d. Briefly outline the team's plan for assembling the device.

4. FEA of Critical Components

Analysis and explanation of refinements for component
Justify necessary changes

a. Provide a list of the four most critical components of the device. Explain their role in the overall design and their likely modes of failure.

b. Explain how the team will attempt to mitigate these failure risks. Consider what can be done during construction as well as what the team can do to prepare for failure during the competition. Explain changes (if any) made to the components as a result of this analysis.

c. If major revisions have been called for at this stage, provide updated solid models.

d. For each critical component, perform Finite Element Analysis on the component. Briefly describe the boundary conditions chosen, justify the analysis choices, and describe input parameters in terms of previous coursework (Statics, Dynamics, DMC, Fluid Mechanics, etc.)

e. Interpret the results of your analysis. Determine if the component (as designed) is likely to fail under the circumstances you will likely encounter on the day of the demonstration. If the component will not fail under those circumstances, use FEA to identify under what circumstances the component would likely fail.

5. Take Aways and Learning Statements

By now you should have gotten the hang of how to do this. If not we urge peer to peer teaching.

a. Learning statements must be a triple, with key words underlined and a single sentence. Show relation to POED.
b. Develop learning statements focusing on the following Principles of Engineering Design: 1d, 3a, 3b and 5b (See Page 1).
c. Individual: Identify at least one Take Away associated with each targeted POED for this assignment. Write a Learning Statement associated with each Take Away. Each team member is required to submit 5 Take Aways and 5 Learning Statements.
d. Team: Choose a single target POED for the team and write a Team Take Away for it. You may submit Team Take Aways for multiple POEDs. Be sure to relate Take Away to POED. No Learning Statement is required.
e. For individual learning statements remember this course is about getting you to internalize the principles of engineering design. Think and write so that you have generated sufficiently insightful lessons learned that can be leveraged in the Semester Learning Essay (Assignment 6)
f. Include full names for each student in the spaces provided in the provided assignment template.

6. Appendix

Relate the detailed drawings to the bill of materials. Stipulate which materials will be used for what components/sub-systems.

a. Include a set of appropriately-detailed engineering drawings (with dimensions and units specified) of all solid model components and assemblies.

b. Label all drawings and use a formatted title block to include information such as team name, component name, scale being used, what units are in use, etc.

c. Drawings should all include multiple views, labelled in appropriate detail.

7. Professionalism

a. Team name, names of members, page number in footer?
b. Question written out then answered?
c. Reality checks undertaken?
d. Clarity, Connectivity, Utility checked?
e. Spark, Insight, Extra Effort evient?

ASSIGNMENT 4 TIPS

1. Read the assignment very carefully and take note of what is required.

2. Reflect on the synthesized concept from Assignment 3.

3. Make a detailed component list for the overall design.

4. Model components individually, giving attention to details like material and physical dimensions. You will be well served for the analysis in A5 to make the component models as accurate as possible.

5. Assemble components into assembly drawing. Note overall design issues and go back to make changes where necessary.

ASSIGNMENT 4 PAGE BREAKDOWN

Item	Section	Suggested Pages
0	Self-grading + Rubric. See Page ??	NA
1	Refined Concept Description	
2	CAD Models	4
3	Bill of Materials	5
4	FEA of Critical Components	2
5	Take Aways and Learning Statements	2
6	Appendix	1
7	Professionalism	11
	NOMINAL TOTAL	NA
		25

Note: for additional material and resources pertaining to finite element analysis, computational fluid dynamics, and computer-aided design, please see ‘CAD/FEA CFD Resources and Materials’ in Section V: Additional Information of this booklet on page 47.

ASSIGNMENT 5: POST-MORTEM ANALYSIS (POED 4A, 4B, 4C, 5A, AND 5C)

Assignment Summary

Following the demonstration of the team's device demonstration, the team must analyze their device in the context of their device's performance during the competition. Teams must look at the design of their device overall and attempt to identify to which stage (or stages) of the process they owe their device's success or failure.

Further, in the context of the Principles of Engineering Design, which describe a structured design process, team's must identify the principles which most contributed to the device's performance and look for ways the design could have been improved.

Target Principles of Engineering Design

4a, 4b, 4c, 5b, and 5c

1. Preamble

Describe the project problem as it was understood by the team. Briefly discuss the strategy employed by the team to solve the problem.

Briefly describe the key characteristics of the team design without discussion of the specific successes or failures of the device.

2. Design Process

Describe what was successfully done during the design process and what failed during the design process. Discuss successes and failures in terms of the assignment objectives and strategies. Discuss how analysis performed during designing was validated or invalidated.

3. Changes to the Design Process

Address two design process issues. First, explore what changes the team could have made during the design process to rectify issues outlined in Step 2. Then, explain how these changes would have resolved the issues. Think about how the analysis could have been modified.

4. Design Artifact

Similar to Step 2, describe what went right with the completed device and explain what went wrong. Think in terms of the process of taking the design from the conceptual to the physical. Further, how was analysis during the prototyping phase validated or invalidated?

5. Changes to the Design Artifact

Address two design artifact issues. First, explore what changes to the device the team could have made to improve demonstration outcomes. Second, explain why these changes could have resolved the issues identified.

6. Take Aways and Learning Statements

For the team, develop one Take Away pertaining to one of the target POEDs for this assignment.

Brainstorm major takeaways from this assignment. Each team member write one take away and thee associated learning statement for each of the target POEDs for this assignment. See table on Page 7...

Note: PLEASE USE THE PROVIDED ASSIGNMENT TEMPLATE, AVAILABLE ON CANVAS

ASSIGNMENT STEP CHECKLIST

Suggested Assignment Length: 10 pages. Grading rubrics are included in the assignment templates and on Page ??

.

1. Preamble

a. Briefly outline the problem as it was understood by the team. Reflect on how the team formulated customer requirements and what they were.

b. This section should be used by the team to reflect upon the design by considering the basis on which it was formed. Tie this into the team's overall design philosophy for the device and briefly describe its characteristics.

c. Do not use this section to describe team successes or failures, only what was done.

d. Consider including both CAD renderings and photos of the finished design. Make sure that they are captioned or are described somehow.

2. Design Process

a. *What Went Right?* In this section, reflect on what went correctly with the design the team implemented. In what ways was the design (not the finished product, necessarily) successful? Be sure to tie the team understanding of the success of the design to specific assignments and lectures over the course of the semester.

b. *What Went Wrong?* Similarly, in this section, explore how the design failed to either meet the team or the instructor standards for the project. What portions of the design process did the team fail to complete or complete adequately? Again, be sure to tie this understanding to the course assignments and lectures.

3. Changes to the Design Process

Tie the proposed changes to relevant POEDs, explaining at what stage in the design process changes would be made and why.

a. *What You Would Change?* Given the responses to the previous two sections, expand on what specific changes the team would make to the design in order to either make it better or to correct a failure. In other words, show that the team could modify the design process to produce your desired change.

b. *How Would These Changes Help?* Reflect on the changes suggested in the previous section and explain how what was identified to improve the design process would have affected the overall design.

4. Design Artifact

a. *What Went Right?* In this section, reflect on what went correctly with the device the team implemented. In what ways was the device successful? Be sure to tie the understanding of the success of the device to specific assignments and lectures over the course of the semester.

b. *What Went Wrong?* Similarly, in this section, explore how the device failed to either meet the team or the instructor standards for the project. What portions of the assembly/construction process did the team fail to complete or complete adequately? Again, be sure to tie this understanding to the course assignments and lectures.

5. Changes to the Design Artifact

a. *What You Would Change?*

i. Given the responses to the previous two sections, expand on what specific changes the team would make to the device in order to either make it better or to correct a failure. In other words, show that the team could modify the device to perform better.

ii. If what the team would change is simply a mechanical fix (use a bigger motor, make the arm stronger, etc.) then explain how the team would modify the design process to be able to generate those mechanical fixes. For example, earlier testing after the CAD phase might have shown that [blank] was needed earlier.

b. *How Would These Changes Help?* Reflect on the changes suggested in the previous section and explain how what was identified would have affected the overall device performance.

6. Learning Statements

Think this through carefully. This is rich material for Assignment 6.

a. Learning statements must be a triple, with key words underlined and a single sentence. Show relation to POED.
b. Develop learning statements focusing on the following Principles of Engineering Design: 4am 4b, 4c, 5b and 5c (See Page 1).
c. Individual: Identify at least one Take Away associated with each targeted POED for this assignment. Write a Learning Statement associated with each Take Away. Each team member is required to submit 5 Take Aways and 5 Learning Statements.
d. Team: Choose a single target POED for the team and write a Team Take Away for it. You may submit Team Take Aways for multiple POEDs. Be sure to relate Take Away to POED. No Learning Statement is required.
e. For individual learning statements remember this course is about getting you to internalize the principles of engineering design. Think and write so that you have generated sufficiently insightful lessons learned that can be leveraged in the Semester Learning Essay (Assignment 6)
f. Include full names for each student in the spaces provided in the provided assignment template.

7. Professionalism

a. Team name, names of members, page number in footer?
b. Questions written out then answered?

c. Reality checks undertaken? Answered prompts satisfactorily?
d. Clarity, Connectivity, Utility checked?
e. Spark, Insight, Extra Effort evident?

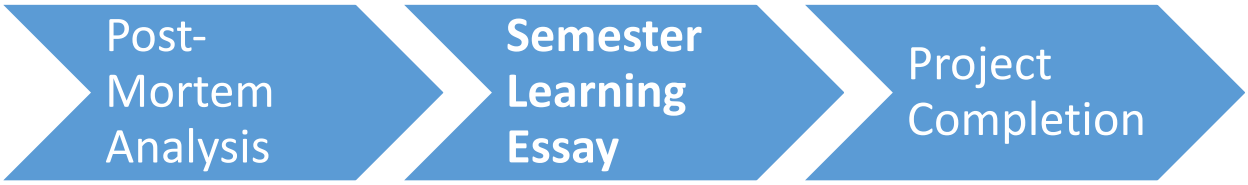
ASSIGNMENT 5 TIPS – LEARN BY REFLECTING ON DOING

1. Reflect on the performance of your team/device during the competition.
2. Reflect on the design process itself and determine where it was successful/unsuccessful.
3. Identify the key points of success/failure in both the design process and the device construction.
4. What changes could have been made to make either component more successful?
5. Explore these successes, failures, and changes in terms of the design process steps and the semester assignments.
6. Assignments 4 and 5 were not scaffolded to the same extent as Assignments 1, 2 and 3. What new POEDs can you identify?
7. Identify Take Aways and Learning Statements. If done well you will have good material for Assignment 6.

ASSIGNMENT 5 PAGE BREAKDOWN

Item	Section	Suggested Pages
0	Self-grading + Rubrics	NA
1	Preamble	2
2	Design Process	2
3	Changes to the Design Process	1
4	Design Artifact	2
5	Changes to the Design Artifact	1
6	Learning Statements	2
8	Professionalism	NA
	NOMINAL TOTAL	10

ASSIGNMENT 6: SEMESTER LEARNING ESSAY (POED 5A, 5B, AND 5C)



Note: PLEASE USE THE PROVIDED ASSIGNMENT TEMPLATE, AVAILABLE ON CANVAS

Preamble

Our goal, in this course, is to provide an opportunity for you as a junior engineer to internalize the Principles of Engineering Design and to develop competencies that you will need to hit the road running as a junior engineer at a corporation in nine months' time.

Take Away and Learning Statement

1. The Learning Statement is anchored in a Take Away. The Learning Statement is a triple that includes Experience, Learning and Value / Utility. You need a good Take Away to write a good Learning Statement.

2. Take Aways and *Learning Statements*: Write the POED to be internalized. After reflecting on doing write the Take Away. Then convert the Take Away into a Learning Statement. Underline / highlight the transition words/phrases. Ensure that the Learning Statement jibes with the targeted POED.

3. Tip for writing Learning Statements: In the context of a POED write a Take Away. Analyze your written Take Away. Identify "Value" – that which helps you grow (gain / further a competency) as a Junior Engineer. Reflect backwards by answering the following questions. What "Learning" is foundational to my attaining this value? What "Experience" is foundational to this lesson I learned? Write forward: Experience / Learning / Value. Note: A Learning Statement is one sentence. You MUST highlight transformative words/phrases. Use variations of the following structure:

Experience x	**Learning y**	**Value / Utility z**
Through **x** (From **x**, By doing **x**, …)	I learned **y**	
I did not consider **x** initially	I realized **y**	Value / utility **z**
I thought (expected) **x** before / initially	I found out **y**	in future of
	I discovered **y**	learning **y**
	I became conscious of **y**	

In **z** emphasis is LESSON of value in FUTURE. A LESSON is generic, can be reused and built upon.

Short Term (Impact in AME4163): Through X I learned Y which will help me do xx in Assignment yy.

Long Term (Impact on career): By doing X in Assignment N, I found out Y which is valuable because (tie to Junior Engineer in industry).

EXAMPLES. PRANAV MOHAN. FALL 2018. TAKE AWAYS DELIBERATELY NOT INLUDED.

POED 1a: **By developing** a Gantt chart that consists of various deadlines for the project, **I learnt** the importance of setting a structure for every project that I work on **which will be valuable to** me as a researcher because I can assess if I am making progress, which will therefore increase my efficiency and better time management when working on long projects. Pranav Mohan. Fall 2018.

POED 2c: **By** continuously having to reality check throughout the design process, **I understood** the importance of stopping and observing what is feasible and what is not, and this is **of great value to me** as it has taught me to stop and reflect while considering long-term ramifications of each and every small step – a skill engineers require on a day to day basis. Pranav Mohan. Fall 2018.

POED 3e: **By** creating multiple criteria for Go/No-Go Matrix in Assignment 3 inspired from the customer requirements of House of Quality in Assignment 1, I **understood** the importance of connecting the early stages of design to later stage and **this is of value to me** as it has taught me to immerse in coherent stages of engineering design where different stages are interconnected to ensure the best quality product is produced.

POED 4b: **By** building a robot that has parts that can be easily changed I **discovered** the importance of standardized parts in the user-centered design to provide greater freedom to the users and **this has added value to** me as an engineer to consider the ease of use of the product when designing a product.

NEW POEDs – PRANAV MOHAN. FALL 2018.

POED 5c: **I did not consider** the importance of building relationship with the team members outside the work environment, however, **I learnt** that by doing so, it increases overall bonding of the team and increases work efficiency which has **empowered me** with the community skill to increase my team's work efficiency and be able to build trust with them.

POED 5d: **I did not consider** meeting agendas to be important and thought that impromptu meetings can also be productive, however, I **realized** that clear and succinct agenda helps provide a structure to the meeting and maintains professionalism and **this is valuable** to me as graduate student as now I can make sure that the results of a meeting are readilyavailable and the meeting proceeds fruitfully.

POED 7c: **By** taking notes in the class on the lecture side, I **realized** that my brain understands concepts much better with visual aid and this proves the creative side in me, and **this is a valuable** experience for me because now I can make sure that when I learn a concept, I draw it out for my long-term memory and as a graduate student teaching in a course, I can facilitate a similar learning opportunity for students.

POED 8d: **By** compiling the learning statements in the form of semester learning essay in the final stage of the Kolb's Experiential Learning Cycle, I **have gained** an insight of recording important knowledge that **will be valuable to** me in future when I will be able to reflect and

immerse in the POEDs as many times as needed and continue to learn from the experiences gained in the past.

Pointers for Assignment 6

1. Four pages maximum. NO cover page. One inch margin all around. Times New Roman 11 point or higher (or equivalent).
2. Maximum number of Take Away and Learning Statements 30. No extra credit for Learning Statements that exceed 30.
3. There is no minimum number of statements required, but each statement will be worth 2 points. For example, 25 statements: 2 x (25/30 points) = 50 points.
4. Each Learning Statement is one complete sentence that covers *Experience* followed by *Learning* followed by *Value* tied to a principle of engineering design**. A Learning Statement must be explicitly related to a POED in the Booklet or classified as a NEW POED.**
5. Key words MUST be highlighted (underlined, made bold, italicized, etc.).
6. Points are given for lessons learned that are associated with the PRINCIPLES OF ENGINEERING DESIGN covered in this class; see Page 1 of Booklet.
7. Number of Categories: You must organize your learning statements into categories. Do not simply list all learning statements without organizing them into categories.
8. You will be assessed based on the number of categories/subjects explored as well as range of POED covered in your learning. See Page 1 of booklet regarding the POED.
9. Numbering in 4 page submissing
    a. Categories 1 through 10. Use Roman numerals. Example I, II, III, IV, V, VI, VII, VIII, IX and X
    b. Take Aways / Learning Statements 1 through 30. Use numbers. Example 1, 2, 3, 4 ……, 28, 29, 30.

Grading Scheme - Components
In Assignment 6 we seek to evaluate what you have learned by reflection on doing in this course

Experience: In the grading scheme this is considered by the categories identified in which the Learning Statements are anchored. Maximum 10 points. Categories include lectures, assignments, team meetings, demonstration, etc.

Learning: In the grading scheme this is considered by the Learning Statements (written as triples) Maximum 30 points.

Value / Utility: Maximum 10 points. Takeaways (0 to 3). Learning Statements (1 to 3). Junior Engineer / Windbag (1 or 2) New POEDs (0 or 1). 5C (0 or 1).

Bonus: Maximum 5 points. Professionalism (template, numbering of Categories and Learning Statements, etc.). Name, email, section number, page number in footer. Best Practice Statements, Insightful Take Aways, etc.

Grade Calculation

Points A (50) = Number of Learning Statements (30) + Number of Categories (10) + Value / Utility (10)

Points B (5) = Bonus for use of template, numbering of Categories and LS, spark

Total Points (105) = 2(Points A) + Bonus Points B

Grade

ame / Section	**Points**
Number of Learning Statements (30)	
Number of Categories / Experiences (10)	
Value / Utility (10)	
Take Aways (0 to 3)	
Learning Statements (0 to 3)	
Junior Engineer / WindBag (1 or 2)	
New POED (0 or 1)	
5C (0 or 1)	
Subtotal	
Subtotal x 2	
Bonus (5)	
Template used	
Categories + LS numbered	
Spark: Takeaways / Best Practice	
Total / Grade	

Professionalism

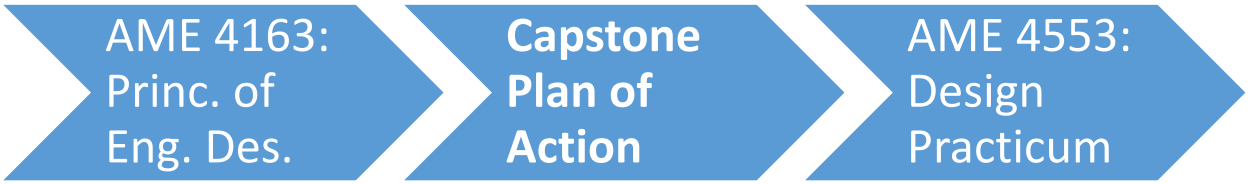
a. Unique to this assignment: two pages MAXIMUM and NO cover page
b. 1-inch margins, Times New Roman 11-point font.
c. Submit as a Microsoft Word document. File name: AME4163_A6_YourFamilyName
d. Properly headed sections
e. Name and page numbers in footer.

ASSIGNMENT 6 TIPS

1. Carefully read to understand what is expected from you for the Semester Learning Essay.
2. Organize lecture material, your notes, and assignments (individual and group).
3. Carefully review, as a team, the material and do a mind dump of what you individually and collectively identify Take Aways from the lectures, the assignments, the feedback, from the design, build and test experiences, meetings with the mentors, etc..
4. Use the affinity diagram to organize the Take Aways with headers being the Categories.

5. Transform the Take Aways into Learning Statements.
6. Prioritize to ensure that you maximize the points you receive.

ASSIGNMENT 7: CAPSTONE PLAN OF ACTION (POED 1A, 1B, 1C, 1D, 5B, AND 5C)



Assignment Summary

By this stage of the course, each junior engineer will have been assigned to a Spring 2017 Capstone project with a team of fellow junior engineers. For Assignment 7, these new teams will have to outline the Capstone project problem as they understand it. This will allow the junior engineers to get a handle on the assignment before the winter break so that they can arrive in January and hit the ground running. The scaffold for this document can be found on the following page. Note: please speak with your Capstone advisor regarding expectations for this assignment, as they may differ from the template laid out here.

Target Principles of Engineering Design

1a, 1b, 1c, 1d, 5b, and 5c

1. Document Format and Problem Statement

Utilize the template provide in the course booklet and Canvas. Include a cover page with the project number, title, company sponsor, faculty advisors, team members, and date. For the first section of the document, copy the problem statement verbatim as provided.

2. Background Information

Research the company divisions or affiliates that the team specifically will be working for as engineering consultants.

In addition, begin to research the problem.

3. Team Understanding

List, in relative detail, what the team understands the problem to be. List what will be expected of the team and the rough timeline to complete it. Show that the team understands the magnitude of the problem that they have been trusted with solving.

4. Requirements List

This should be a chart with multiple sections for different types of requirements. Make sure that the team differentiates between Demands and Wishes as well as which team members will serve as leads on specific components of the list.

5. Questions for Sponsor

Prepare a series of questions that the team will ask the company sponsor in order to better understand the problem. Use this opportunity to clarify the company expectations, budget, communication frequency and protocols, etc.

6. Plan of Action

Develop a plan, a series of distinct steps which will then be used to begin approaching the problem. If it is possible or useful to the team, differentiate between near-term plans and long-term plans and give estimated dates of completion of these tasks.

7. Important Milestones

List out all the important milestones for the Capstone project. With the exception of the interdisciplinary teams, all important dates should be available to the teams by this point.

8. Critical Evaluation

Reflect on the work so far and evaluate what the team has determined. What are the likely points of failure for the team? Where and when will the process break down or become strained? What can be done to eliminate or minimize these issues?

9. Take Aways and Learning Statements

For the team, develop one Take Away pertaining to one of the target POEDs for this assignment.

Brainstorm major takeaways from this assignment. Each team member write one take away and thee associated learning statement for each of the target POEDs for this assignment. See table on Page 7...

For those who will not be taking AME4553 in Spring 2020 we have prepared an Alternate Assignment 7 for you. See Page ??.

Note: PLEASE USE THE PROVIDED ASSIGNMENT TEMPLATE, AVAILABLE ON CANVAS

ASSIGNMENT STEP CHECKLIST

This assignment is patterned after Assignment 1. Suggested Length: 15 Slides/Pages (ask for clarification from faculty mentor). Grading rubrics are included in the assignment templates and on Page ??.

Use the template provided (available on Canvas) to complete the steps of the assignment.

1. Document Format and Problem Statement
a. Include a cover page with project number, project name, company sponsor, company advisors, faculty advisors, team member names, and the date b. Reproduce, verbatim, the problem statement as provided in AME4163.
Problem Statement:
2. Background Information
a. Do some research into the company, including who they are, where they're located, what size of business they are, who they market to, etc. b. Research the problem. Is it a costly problem for the company? What are the safety and/or ethical concerns associated with the problem and/or its possible solution? What prior work has already been done? c. Use this as an opportunity to learn as much as possible about the company before meeting them in person.
Company Research: *Problem Research:*
3. Team Understanding
a. Based on the team understanding of the problem statement as provided and the background information so far explored, explain what the team understands the problem for the company to be. b. More specifically, think in terms of what value the team can provide the company. Think about whether or not they would benefit from a prototype or more involved analysis, for example.
Team Understanding of Problem: *Value Opportunity:*

4. Requirements List

a. Leverage the team understanding of the problem as well as the background research performed to establish a Requirements List. This list should be as comprehensive as possible.
b. Use the Demands/Wishes distinction used in the AME4163 project. Further, categorize requirements as functional, technical (ergonomic, buildable, maintainable, safe) economical, etc.
c. Establish target objectives for the achievement of the requirements present on the list.

Member A Member B Member C		**Requirements List** Capstone Project Name	*Date*
Revisions	W/D	Requirements	Lead Team Member
Category (Example: Planning Requirements)			
12/3/16	W	Requirement Description – Target	Member A
12/3/16	D	Requirement Description – Target	Member B
…	…	…	…
Category (Example: Technical Requirements)			
12/3/16	D	Requirement Description – Target	Member C
12/3/16	D	Requirement Description – Target	Member D
…	…	…	…

5. Questions for Sponsor

a. Use this opportunity to establish an early relationship with the company sponsors; these are professionals using their time and experience to assist students in becoming junior engineers.
b. Questions for the sponsor should be as specific as is feasible while focusing on issues not easily researched or answerable through analysis. In other words, ask only questions that the sponsor can provide answers for.
c. Do not make the list for this assignment too exhaustive, focus on the important questions needed to start making progress as quickly as possible.

Questions:

1. Category 1
    a. Question 1A
    b. Question 1B
2. Category 2
    a. Question 2A
    b. Question 2b

6. Plan of Action

a. Consider the remaining Fall 2019 schedule as well as the Spring 2020 schedule.
b. Discuss here the elements of the team contract and how they will be implemented.
c. Develop a Gantt chart and an expected hours breakdown for the project. This will change as you go along, but start it here.

Project Gantt Chart:

7. Important Milestones
a. You can find the majority of these dates in the Capstone Handbook, which will be available on Canvas. b. Highlight dates of project deliverables.
Project Milestones: a. Academic Calendar Events (Semester start/end dates, etc.) b. Deliverable Deadlines (AME4553/Company Deliverables)
8. Critical Evaluation
a. Recall the various reality checks performed during the design of the AME4163 project device. Think about how the team considered ways the device could fail long before it was built. b. Categorize the different ways the project could fail. Some examples include planning issues, scope creep, and poor communication. Think through the various possibilities and anticipate them.
Critical Evaluation of Plan of Action: *Probable Failure Modes:*
9. Learning Statements
a. Team: Prepare a single team Take Away based on one of the target POEDs for the assignment b. Individual: See prompt on Assignment 1, Page 19.
Team Take Away: *Individual Take Aways and Learning Statement*

10. Professionalism

a. Team name, names of members, page number in footer?
b. Questions written out then answered?
c. Reality checks undertaken? Answered prompts satisfactorily?
d. Clarity, Connectivity, Utility checked?
e. Spark, Insight, Extra Effort evident?

ASSIGNMENT 7 TIPS

1. Begin approaching the Capstone problem using the tools acquired in AME4163.
2. Consider the customer requirements and your own requirements as junior engineers.
3. Reflect on the problem statement as delivered and develop a full understanding of the problem.
4. Work with your teammates to develop an understanding of the problem.
5. Plan the next stages for your team in terms of both the time you will have to devote to the project as well as your current understanding.

ASSIGNMENT 7 PAGE BREAKDOWN

The page breakdown for this assignment will be left to the best judgement and discretion of the team's capstone faculty mentor. Please inquire with him or her for further details.

ALTERNATE ASSIGNMENT 7: THOSE NOT TAKING AME4553 DESIGN PRACTICUM IN SPRING 2020

All students enrolled in AME4163 are required to do Assignment 7 – Plan of Action or equivalent that constitutes 7% of the final grade.

We understand that some of you will NOT be taking AME4553 – Design Practicum next semester. Hence, we require you to do another assignment that is equivalent to the Plan of Action.

We invite those needing to submit an alternate Assignment 7 to suggest themes for their 5 to 10 page essays. Hence this email. We are keen that the essay you write is anchored in AME4163 and is of benefit to you in the future. Some suggestions for themes:

1. Some visiting students are required to submit a report to their sponsor upon their return. Should you decide to take this option please ensure that you relate the Principles of Engineering Design you have internalized to some aspect of your further studies.
2. Students in Engineering Physics take AME4163 as an elective and do their capstone in their own schools. They may wish to write an essay on how the Principles of Engineering Design could be augmented by what they have learned in Engineering Physics OR how they could use Principles of Engineering Design in designing an experiment in physics.
3. Students who are transferring from one degree to another may wish to write an essay on how the Principles of Engineering Design could be used in the discipline they are transferring from.

The preceding are suggestions. We are open to suggestions from you.

ACTION ITEMS – ALTERNATE ASSIGNMENT 7

1. Please send Professor Mistree a title and abstract of the essay you plan to write as an Alternate Assignment 7. He would much appreciate getting this by December 1, 2019 , 11:59 PM. Please include your telephone number in your submission. Please follow the following communication protocols.

   Subject Line: AME4163 – Assignment 7 Alt – FAMILY NAME
   File Name: AME4163_Assignment7Abstract_FAMILYNAME
2. If you would like to talk please email or call Professor Mistree so you can talk and agree on a theme.

V. SELF-EVALUATION AND RUBRICS FOR ASSIGNMENTS

Preamble

In your professional careers you will be called on to evaluate proposals, the work of others, and your own. How can you be trusted to evaluate the work of others if you are unable to critically evaluate your own work? In response to the preceding rhetorical question we offer you the opportunity to learn how to evaluate. To be evaluate a person, proposal or thing there MUST be a rubric. We have created a rubric for each assignment. In AME4163 you need to use this rubric in three ways:

1. As prompts for you to deliver what is expected of you. Use these prompts in your planning.
2. As a scale for you to evaluate your work.
3. As a way to summarize the evaluation (in the context of the rubric) of your submission.

Start each submission with the completed self-evaluation sheet followed by the rubric marked up to support your evaluation in each category on self-evaluation form.

ASSIGNMENT 1 SELF EVALUATION

Team Number:		**Date:**	
Assignment:		**Evaluator:**	

Assignment Outcome	**Performance Criteria**	**Assessment (Circle One)**	**In context of rubric justify evaluation**
1a	Team skill inventory	Unsatisfactory Developing Satisfactory Exemplary	
1b	Team Contract Understanding	Unsatisfactory Developing Satisfactory Exemplary	
1c	Problem Statement	Unsatisfactory Developing Satisfactory Exemplary	
1c	House of Quality	Unsatisfactory Developing Satisfactory Exemplary	
1c	Requirements List	Unsatisfactory Developing Satisfactory Exemplary	

1d	Project Schedule	Unsatisfactory Developing Satisfactory Exemplary	
1d	Division of Labor	Unsatisfactory Developing Satisfactory Exemplary	
5b	Learning Statements (Team)	Unsatisfactory Developing Satisfactory Exemplary	
5b	Learning Statements (Individual)	Unsatisfactory Developing Satisfactory Exemplary	

ASSIGNMENT 1 POED RUBRIC

Student outcomes assessed in Assignment 1 (POED)

1. Planning a Design Process
    a. Forming a team
    b. Accepting and executing a team contract to stipulate ethical guidelines to decision making and problem resolution
    c. Understanding the problem and framing the problem statement
    d. Proposing a plan of action
5. Learning through doing, reflecting, and articulating
    b. Articulating, using learning statements, the Principles of Engineering Design that you have internalized

Assignment Outcome -1a-

Planning a design process – Forming a Team

Performance Criteria

- Team skill inventory and prospectus: Discuss amongst the team each member’s skills which are pertinent to engineering design. Take a thorough inventory of the skills the team brings to bear as a whole. Write a paragraph for each team member.

Unsatisfactory	Developing	Satisfactory	Exemplary
Students do not have an understanding of the team skills and strengths. Further, they have not placed	Team has listed their skills, strengths with no effort to contextualize/integrate those skills as team assets	The Team has developed a good list of skills and strengths. They have made some effort to place these in a team context	Team has provided both a comprehensive list of skills and have determined how these skills can be leveraged together in the project.

what information they have in any context.			

Assignment Outcome -1b-

Planning a design process – Accepting and executing a team contract to stipulate ethical guidelines to decision making and problem resolution

Performance Criteria

- Team Contract Understanding - A team contract document has been provided to all teams. Read through the document, discuss its points, and form an understanding of how the team can best leverage the procedures laid out there. In the submission, include a description of the roles assigned to specific team members, a statement attesting the contract, and a paragraph describing changes.

Unsatisfactory	Developing	Satisfactory	Exemplary
Team has made few, if any changes and have not done anything to indicate mutual understanding of the shared contract	Team has indicated a mutual understanding of the document but have not taken ownership by shaping it to suit their needs	Team has indicated mutual understanding and have made changes but these changes are largely superficial or basic	Team has both indicated mutual understanding/acceptance of the contract and have made changes to suit their team’s unique needs.

Assignment Outcome -1c-

Planning a design process – Understanding the problem and framing the problem statement

Performance Criteria

- Problem Statement – As a team, discuss the problem in the context that the device functions. Develop a statement describing the team understanding of these functions. After completing the HOQ and Req. List, revisit the problem statement and revise in terms of the customer needs. Include BOTH in the final submission.

Unsatisfactory	Developing	Satisfactory	Exemplary
Both versions of the problem statement are simplistic and simply restate the provided problem. There is little meaningful difference between the two.	Team has used the HOQ and Requirements List to modify their original problem statement but the statement has largely focused on simple technical questions	The revised problem statement reflects some level of insight gleaned from the HOQ and Requirements List analysis. Still relies heavily on the instructor provided statement.	The revised problem statement reflects a comprehensive understanding of who the customers are and what they need. The statement expresses an understanding of the problem which reaches beyond the technical challenges.

Assignment Outcome -1c-

Planning a design process – Identifying the Customers and Prioritizing Requirements (HOQ)

Performance Criteria • House of Quality – Using the provided problem statement, the first problem statement provided by the team, and further analysis, identify the customers: who they are, what they want, and how important those items are. Put these into the HOQ format and compare the what's and how's, the how's and how's, etc.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
The provided House of Quality is either not completed or given only token attention. The chart is incomplete or excessively simplistic	Some effort has been made to fill in the chart but analysis is lacking significant detail and HOQ comparisons are simplistic.	Team has managed to identify several who's and requirements that are not explicitly mentioned in the problem background	Team has provided a comprehensive HOQ chart with several 'who's', numerous 'what's' and 'how's' and a large body of comparisons with justification provided.

Assignment Outcome -1c-

Planning a design process – Understanding and categorizing the comprehensive set of requirements (Requirements List)

Performance Criteria • Requirements List – Based on the results of the HOQ, develop a requirements list for the project. Categorize requirements in terms of wants and needs as well as relevant categories (technical, manufacturing, aesthetic, etc.). Build a list that makes sense given your analysis and unique skillsets.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
Requirements List is missing categorization (wants vs. demands, requirement grouping, etc.), provides little detail, and/or only identifies obvious (provided) requirements	Requirements List has some level of organization (categorization, formatting, etc.) but provides few target objectives or requirements not provided by the instructors	Team has identified key requirements not provided by instructors and categorized them in relevant ways but have not set adequate targets or assigned individual requirements to specific team members	Requirements List is comprehensive, well organized, identifies requirements from multiple customers, sets reasonable goals/targets, and have broken tasks up among the group members.

Assignment Outcome -1d-

Planning a design process – Proposing a plan of action (Gantt Chart)

Performance Criteria • Project Schedule – Create a Gantt Chart detailing the actions that will be required to complete the course project. This chart should include budgeted time for designing,

building, and testing the mechanism. This document will be updated and kept throughout the semester.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
Team has created a project schedule but have not included any items beyond assignments and provided milestone dates (e.g., competition day)	Team has identified milestones not explicitly provided but have given only cursory attention to budgeted time, task sequence, and or the number of sub-steps.	Team has included some details of a design process, including steps not explicitly provided by instructors. They have budgeted time for tasks but have not done so realistically or with foresight.	Team has produced a realistic and detailed timeline of the project tasks and goals. They have included both provided milestones and identified steps of the design project in detail.

Assignment Outcome -1d-

Planning a design process – Proposing a plan of action (Division of Labor)

Performance Criteria • Division of Labor – Along with the tasks laid out in the Gantt Chart, craft tasks in terms of the team members as individual task leads (who will be in charge of what portion of the project).			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
Team has not provided a breakdown of which team members will be involved in which task	Team has provided a breakdown of labor but the breakdown is either grossly skewed for/against one or more students or is not justified by the Gantt chart tasks	Breakdown of labor is relatively fair and evenly assigned but differs in some way from the Gantt chart or lacks some justification	Breakdown of labor is fairly distributed, tied to the Gantt chart tasks, and is well justified

Assignment Outcome -5b

Learning through doing, reflecting, and articulating - Articulating, using learning statements, the Principles of Engineering Design that you have internalized (team)

Performance Criteria • Learning Statements (team) – for the team, develop several learning statements pertaining to one of the target POED’s for this assignment.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**

Team has not provided team learning statements in any fashion	Team learning statements do not follow the learning statement structure or describe obvious, explicit learning	Team learning statements are formatted correctly and express insight but are not well connected to the POED’s	Team learning statements are both insightful and tied well to the POED’s. Learning expressed makes wider connections.

Assignment Outcome -5b

Learning through doing, reflecting, and articulating - Articulating, using learning statements, the Principles of Engineering Design that you have internalized (individual)

Performance Criteria • Learning Statements (individual) – For each team member, develop several learning statements pertaining to one of the target POED’s for this assignment.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
Team has not provided individual learning statements in any fashion	Individual learning statements do not follow the learning statement structure or describe obvious, explicit learning	Individual learning statements are formatted correctly and express insight but are not well connected to the POED’s	Individual learning statements are both insightful and tied well to the POED’s. Learning expressed makes wider connections.

ASSIGNMENT 2 SELF EVALUATION

Team Number:		**Date:**	
Assignment:		**Evaluator:**	

Assignment Outcome	**Performance Criteria**	**Assessment (Circle One)**	**In context of rubric justify evaluation**
1d	Function Structure	Unsatisfactory Developing Satisfactory Exemplary	Maximum 16
2a	Reality Check (Function structure vs. Req. list)	Unsatisfactory Developing Satisfactory Exemplary	Maximum 8
2a	Morphological Chart	Unsatisfactory Developing Satisfactory Exemplary	Maximum 12

2a	Concept Generation (via Morph. Chart)	Unsatisfactory Developing Satisfactory Exemplary	Maximum 16
2b	Plus, Minus, Interesting	Unsatisfactory Developing Satisfactory Exemplary	Maximum 12
2b	Concept Sketches	Unsatisfactory Developing Satisfactory Exemplary	Maximum 4
5b	Learning Statements (Team)	Unsatisfactory Developing Satisfactory Exemplary	Maximum 2
5b	Learning Statements (Individual)	Unsatisfactory Developing Satisfactory Exemplary	Maximum 6
Professionalism		Unsatisfactory Developing Satisfactory Exemplary	Maximum 4

TOTAL = Percentage

ASSIGNMENT 2 RUBRIC

Assignment Outcome -1d

Planning a design process – Proposing a plan of action (Function Structure)

Performance Criteria

- Function Structure: In the context of the Requirements List, outline the functions of the completed device and divide into sub-functions. Describe functions in terms of how material, energy, and information flow through the process. Construct a diagram which traces these sub-functions throughout the system.

Assignment Outcome -2a

Preliminary Design – Ideation: generating concepts

Performance Criteria

- Reality Check: Using the Requirements list, ensure that the sub-functions identified meet the target performance requirements. Check the logic and order of the functions to identify possible corrections.

Assignment Outcome -2a

Preliminary Design – Developing Concepts: generating concepts

Performance Criteria
• Morphological Chart: The sub-functions in the Function Structure diagram will be used to generate the Morphological Chart. Each sub-function will become a row in the Morphological Chart. For each row, list several specific ways to accomplish each sub-function and describe each in detail. In the context of the Requirements List comment on why the Morph Chart is correct.

Assignment Outcome -2a

Preliminary Design – Ideation: generating concepts

Performance Criteria
• Concept Generation: Go through the Morphological Chart randomly from top to bottom to generate at least six concepts for their device. Indicate the approach used. Describe how each concept works.

Assignment Outcome -2b

Preliminary Design – b. Developing concepts: Ensure functional feasibility, ensure realizability (technical feasibility)

Performance Criteria
• Plus, Minus, Interesting: For each concept, create a list outlining the plusses, minuses, and most interesting points for each concept.Be sure to look at sub-function mechanisms to determine plusses (advantages) and minuses (disadvantages) of the various configurations. Focus on functional feasibility and speculate about technical feasibility and buildability.

Assignment Outcome -2b

Preliminary Design – b. Developing concepts: concept sketches anchored in the morph chart, description of how it works using tuples.

Performance Criteria
• Concept Sketches: Including sketches tied to the morph chart and how each works. Sketches should be clear, labeled and understandable.

Student outcomes assessed in Assignment 2 (POED)

1. Planning a Design Process
    d. Proposing a plan of action
2. Preliminary design
    a. Ideation – generating concepts
    b. Developing concepts: Ensure functional feasibility, ensure realizability (technical feasibility)
    c. Evaluating the concepts (functional feasibility, technical feasibility) and identifying those system concepts most likely to succeed.
5. Learning through doing, reflecting, and articulating
    b. Articulating, using learning statements, the Principles of Engineering Design that you have internalized

Assignment Outcome -5b

Learning through doing, reflecting, and articulating - Articulating, using learning statements, the Principles of Engineering Design that you have internalized (team)

Performance Criteria

- Take Away (team) – for the team, develop several learning statements pertaining to one of the target POED's for this assignment.

Assignment Outcome -5b

Learning through doing, reflecting, and articulating - Articulating, using learning statements, the Principles of Engineering Design that you have internalized (individual)

Performance Criteria

- Learning Statements (individual) – For each team member, develop several learning statements pertaining to one of the target POED's for this assignment.

ASSIGNMENT 3 SELF-EVALUATION

Team Number:		**Date:**	
Assignment:	3	**Evaluator:**	

Assignment Outcome	**Performance Criteria**	**Assessment (Circle One)**	**In context of rubric justify self-evaluation**
Item 1: 1d	Available Assets	Unsatisfactory Developing Satisfactory Exemplary	Maximum 12
Item 2: 3a	Critical Evaluation of Concepts (sketches, sub-functions, etc.)	Unsatisfactory Developing Satisfactory Exemplary	Maximum 20 (From Assignment 2)
Item 3: 3a	Evaluation Criteria/Threshold for Go	Unsatisfactory Developing Satisfactory Exemplary	Maximum 12
Item 4 and 5: 3a	Go/No-Go Matrix + Explanation	Unsatisfactory Developing Satisfactory Exemplary	Maximum 16
Item 6: 3a	PMI/Probable Failure Modes for selected concepts	Unsatisfactory Developing Satisfactory Exemplary	Maximum12
Item 7: 3b	Justification for selected concepts (materials, assets, etc.). Reality check. Process Decision Program Chart	Unsatisfactory Developing Satisfactory Exemplary	Maximum 12
Item 8: 5b	Learning Statements (Team)	Unsatisfactory Developing Satisfactory Exemplary	Maximum 4
Item 9: 5b	Learning Statements (Individual)	Unsatisfactory Developing Satisfactory Exemplary	Maximum 8
Best Practice Special Professionalism			Maximum 4

TOTAL MAX 100 PERCENTAGE

ASSIGNMENT 3 RUBRIC FOR EVALUATION

To have grade count for Assignment 2 ensure connectivity between Assignment 2 and Assignment 3.

Item 1 - Assignment Outcome -1d

Planning a design process – Proposing a plan of action anchored in Available Assets

Performance Criteria
• Available Assets: Develop a list of available team assets. This should include available tools and materials immediately available to the team. Perform an inventory of this list and categorize these items based on availability, utility, cost, etc. Create a table which combines this asset list with the skills inventory from A1.

Item 2 - Assignment Outcome -3a

Embodiment Design – Refining / modifying the most likely to succeed concept through technical analysis, experimentation and thought exercises

Performance Criteria
• Critical Evaluation of the Concepts: Reproduce sketches and descriptions from A2. Use these items to explore areas of success and failure for each concept. Do not just focus on failure on a technical level; consider how a complex concept may not be feasible in the available time, for example. Consider all the ways a concept could fail; use Process Decision Program Chart.

Item 3 - Assignment Outcome -3a

Embodiment Design – Refining / modifying the most likely to succeed concept through technical analysis, experimentation and thought exercises

Performance Criteria
• Establish Evaluation Criteria: Identify and describe a prioritized list of criteria that will be used in the Go/No Go analysis. This should include both requirements from the Requirements List and insights gleaned from the previous step. Describe these criteria and justify their inclusion. Include threshold for Go. Perform a reality check on the criteria to identify anything missing.

Item 4 - Assignment Outcome -3a

Embodiment Design – Refining / modifying the most likely to succeed concept through technical analysis, experimentation and thought exercises

Performance Criteria
• Go/No-Go Matrix: Create a table with the evaluation criteria and the concepts. For each concept, at every row of the evaluation criteria put a 'Go' in the cell if the concept meets the criteria and a 'No Go' if it does not.

Item 5 - Assignment Outcome -3a

Embodiment Design – Refining / modifying the most likely to succeed concept through technical analysis, experimentation and thought exercises

Performance Criteria

- Go/No Go Justification: In text below the Go/No-Go Matrix chart, justify your Go/No Go decisions.

Item 6 - Assignment Outcome -3a

Embodiment Design – Refining / modifying the most likely to succeed concept through technical analysis, experimentation and thought exercises

Performance Criteria

- Reduce the Number of Concepts (PMI/Probable Failure Modes): Reduce the Number of Concepts. Using your Go/No Go results, rank your concepts in order of their likelihood to succeed. Select the top two concepts, perform PMI, and explore their probable failure modes. Explain how these failure modes can be prevented or minimized.

Item 7 - Assignment Outcome -3b

Embodiment Design – Stipulating a Bill of Materials

Performance Criteria

- Reduce the Number of Concepts (Justification/plan moving forward): Justify your primary and secondary concept.

Student outcomes assessed in Assignment 3 (POED)

1. Planning a Design Process
    d. Proposing a plan of action
3. Embodiment design
    a. Refining / modifying the most likely to succeed concept through technical analysis, experimentation and thought exercises
    b. Stipulating a Bill of Materials
5. Learning through doing, reflecting, and articulating
    b. Articulating, using learning statements, the Principles of Engineering Design that you have internalized

Item 8 - Assignment Outcome -5b

Learning through doing, reflecting, and articulating - Articulating, using learning statements, the Principles of Engineering Design that you have internalized (team)

Performance Criteria

- Take Away (team) – for the team, develop several learning statements pertaining to one of the target POED's for this assignment.

Item 9 - Assignment Outcome -5b

Learning through doing, reflecting, and articulating - Articulating, using learning statements, the Principles of Engineering Design that you have internalized (individual)

Performance Criteria

- Learning Statements (individual) – For each team member, develop several learning statements pertaining to one of the target POED's for this assignment.

ASSIGNMENT 4 SELF-EVALUATION

Team Number:		**Date:**	
Assignment 4		**Evaluator:**	

Assignment Outcome	**Performance Criteria**	**Assessment (Circle One)**	**In context of rubric justify self-evaluation**
1d, 3a	Refined Concept Descriptions CAD Models	Unsatisfactory Developing Satisfactory Exemplary	
3b	Bill of Materials	Unsatisfactory Developing Satisfactory Exemplary	
3c	FEA of Critical Components (Team)	Unsatisfactory Developing Satisfactory Exemplary	
3c	FEA of Critical Components (Individual)	Unsatisfactory Developing Satisfactory Exemplary	Name:
3c	FEA of Critical Components (Individual)	Unsatisfactory Developing Satisfactory Exemplary	Name:
3c	FEA of Critical Components (Individual)	Unsatisfactory Developing Satisfactory Exemplary	Name:
3c	FEA of Critical Components (Individual)	Unsatisfactory Developing Satisfactory Exemplary	Name:
3c	FEA of Critical Components (Individual)	Unsatisfactory Developing Satisfactory Exemplary	Name:
5b	Learning Statements (Team)	Unsatisfactory Developing Satisfactory Exemplary	
5b	Learning Statements (Individual)	Unsatisfactory Developing Satisfactory Exemplary	

3a	Appendix (Detail Engineering Drawings)	Unsatisfactory Developing Satisfactory Exemplary	

ASSIGNMENT 4 POED RUBRIC

Student outcomes assessed in Assignment 4 (POED)

1. Planning a Design Process
    d. Proposing a plan of action
3. Embodiment design
    a. Refining / modifying the most likely to succeed concept through technical analysis, experimentation and thought exercises
    b. Stipulating a Bill of Materials
    c. Ensuring functional feasibility, functional feasibility, safety, and buildability
5. Learning through doing, reflecting, and articulating
    b. Articulating, using learning statements, the Principles of Engineering Design that you have internalized

Assignment Outcome -1d, 3a

Planning a design process – Proposing a plan of action

Embodiment Design – Refining/modifying the most likely to succeed concept through technical analysis, experimentation and thought exercises

Performance Criteria

- Refined Concept Description: Reintroduce the concept selected with a sketch and a short description of the key functionality of the concept. If changes to the concept have been made since A3, describe those changes and justify them.
- CAD Models: Use a CAD software program to develop solid models for all relevant components in the concept. Additionally, use these models to form assemblies, including an assembly of all components. When possible, specify materials and colors so as to make the final assembly more clear.

Unsatisfactory	Developing	Satisfactory	Exemplary
The team has provided no or only a cursory refined concept description. Any CAD models (if any are provided) lack sufficient detail (sub-function structures, non-mechanical components, etc.). It does not appear that the team is ready to	The team has provided a refined concept description and some CAD models. The provided materials cover more detail than bare essentials but are lacking significant detail. The team's selected concept does not appear quite ready to move forward with into building/testing.	The team has provided a refined concept description and CAD models with good levels of detail. They may be missing certain key details or critical features. The team should be able to proceed with the selected concept if they think carefully	With the refined concept description and CAD models the team demonstrates a detailed and well-thought out potential concept. They have explored the concept in sufficient detail and have indicated a plan to realize said concept which is realistic and

move forward with the selected concept.		about possible modes of failure.	makes room for possible failure modes.

Assignment Outcome -3b

Embodiment Design – Stipulating a Bill of Materials

Performance Criteria • Bill of Materials: Generate a preliminary Bill of Materials, citing specific items the team intends to use to build the device. Try to focus heavily on the team's available assets and existing skills.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
The team has provided no or only a scant Bill of Materials. The list does not cover all materials needed to realize the selected concept. Furthermore, the team has only described selected materials generally (example: "motor" instead of "Model aXX24 DC motor size A"). The team has not leveraged their existing assets and/or skills.	The team has provided a Bill of Materials but a significant level of detail appears to be missing: the team has not considered specific selections in all or in part and they have not made a significant effort to leverage their team assets and skills as identified from previous assignments	The team has provided a Bill of Materials with a good level of detail. Certain oversights have been made. For example, "simple" components are only identified generally without specific choices identified in some cases. The team could do more to connect to team assets and skills.	The team has provided a Bill of Materials which will enable the team to fully realize the selected concept. In addition, all materials on the provided list are identified specifically. Finally, the team has heavily leveraged their existing assets and skills into their material selections.

Assignment Outcome -3c

Embodiment Design – Ensuring functional feasibility, functional feasibility, safety, and buildability

Performance Criteria • FEA of Critical Components (Team Portion): Select several specific components (parts) of the finished CAD model (as many as there as there are team members) and briefly discuss their function in the overall system and their probable failure modes.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
The team has selected fewer than five components and not discussed their function in significant detail. The reader has little idea how the	The team has selected five critical components but have not given sufficient detail regarding each part's role in the overall system. The	The team has selected five critical components and provided a good amount of detail regarding the components role in the	The team has selected five components which were previously generated. The parts have been rendered in excellent detail and the team has described the

component fits into the overall function of the concept. Failure risks and mitigation are given no or only cursory attention.	team is missing significant exploration of failure risks and mitigation strategies.	overall concept. The team has explored failure risks and mitigation strategies but have missed some key points.	role of all the critical components in their respective sub-system. Failure risks have been identified and addressed well.

Assignment Outcome -3c

Embodiment Design – Ensuring functional feasibility, functional feasibility, safety, and buildability

Performance Criteria • FEA of Critical Components (Individual Portion): Individual team members will then choose a component and perform FEA. Identify boundary conditions and justify inputs.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
Individual has not included a satisfactory submission demonstrating results from a FEA simulation or has given only made a cursory attempt (i.e., the problem is overly simplistic, lacking defined boundary conditions, or shows absurd or un-assessed results).	The individual has a provided an FEA report which is tied to one of the identified critical components. However, the report has largely misapplied boundary conditions, problem setup, or has interpreted results grossly incorrectly.	The individual has provided an FEA report which demonstrates a satisfactory understanding of the role of FEA simulation but could use more detail in the area of either problem setup, engineering background theory, or results interpretation.	The individual has provided an FEA report for one of the critical components which intelligently sets up the FEA simulation analytically, identifies boundary conditions, describes the engineering theory behind the analysis, and correctly interprets the provided results.

Assignment Outcome -5b

Learning through doing, reflecting, and articulating - Articulating, using learning statements, the Principles of Engineering Design that you have internalized (team)

Performance Criteria • Learning Statements (team) – for the team, develop several learning statements pertaining to one of the target POED’s for this assignment.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
Team has not provided team learning statements in any fashion	Team learning statements do not follow the learning statement structure or describe obvious, explicit learning	Team learning statements are formatted correctly and express insight but are not well connected to the POED’s	Team learning statements are both insightful and tied well to the POED’s. Learning expressed makes wider connections.

Assignment Outcome -5b

Learning through doing, reflecting, and articulating - Articulating, using learning statements, the Principles of Engineering Design that you have internalized (individual)

Performance Criteria • Learning Statements (individual) – For each team member, develop several learning statements pertaining to one of the target POED's for this assignment.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
Team has not provided individual learning statements in any fashion	Individual learning statements do not follow the learning statement structure or describe obvious, explicit learning	Individual learning statements are formatted correctly and express insight but are not well connected to the POED's	Individual learning statements are both insightful and tied well to the POED's. Learning expressed makes wider connections.

Assignment Outcome -3a

Embodiment Design – Refining / modifying the most likely to succeed concept through technical analysis, experimentation and thought exercises

Performance Criteria • Appendix: In an appendix section, include engineering drawings of all parts and assemblies created during modeling. Be sure to include in each drawing a title block with scale, date, team name, part name, etc.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
The team has provided no or too few engineering drawings. What are provided are unprofessional: lacking labels, figures, or keys.	The team has provided engineering drawings for all components but drawings lack significant detail: labels, title blocks, etc.	The team has provided engineering drawings for all components but there are some inconsistencies between drawings: poor labelling, differing units, etc.	The team has provided detailed engineering drawings of all CAD models for all system components. Drawings are labeled, consistent, and professional.

ASSIGNMENT 5 SELF-EVALUATION

Team Number:		**Date:**	
Assignment 5		**Evaluator:**	

Assignment Outcome	**Performance Criteria**	**Assessment (Circle One)**	**Comments**
4a, 4b	Preamble	Unsatisfactory Developing Satisfactory Exemplary	

4c (i)	Design Process	Unsatisfactory Developing Satisfactory Exemplary	
4c (ii)	Changes to the Design Process	Unsatisfactory Developing Satisfactory Exemplary	
4c (iii)	Design Artifact	Unsatisfactory Developing Satisfactory Exemplary	
4c (iv)	Changes to the Design Artifact	Unsatisfactory Developing Satisfactory Exemplary	
5b	Learning Statements (Team)	Unsatisfactory Developing Satisfactory Exemplary	
5b	Learning Statements (Individual)	Unsatisfactory Developing Satisfactory Exemplary	
5b	Learning Statements (Individual)	Unsatisfactory Developing Satisfactory Exemplary	
3a	Appendix (Detail Engineering Drawings)	Unsatisfactory Developing Satisfactory Exemplary	

ASSIGNMENT 5 POED RUBRIC

Student outcomes assessed in Assignment 5 (POED)

4. Prototyping, testing and post-mortem analysis
    a. Creating a bill of materials as built, including an understanding of the limitations and capabilities of the chosen components
    b. Ensuring that the design as built meets target performance requirements
    c. Performing a critical analysis after device prototyping of causes of success and failure
5. Learning through doing, reflecting, and articulating
    b. Articulating, using learning statements, the Principles of Engineering Design that you have internalized

Assignment Outcome - 4a, 4b

Prototyping, testing and post-mortem analysis – Creating a bill of materials as built, including an understanding of the limitations and capabilities of the chosen components – Ensuring that the design as built meets target performance requirements

Performance Criteria • Preamble: Describe the project problem as it was understood by the team. Briefly discuss the strategy employed by the team to solve the problem. Briefly describe the key characteristics of the team design without discussion of the specific successes or failures of the device.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
The team has provided no description of the group understanding of the problem and the design philosophy that they employed. If they have included this section, they have only used it to describe the device as built with no context or description of the process utilized present. Further, the team uses this space primarily to discuss the success or failure of the device.	The team has written, to some degree, about the design philosophy/process they employed along with the team understanding of the problem. However, the descriptions for both are either lacking significant detail or lack connectivity with the description of the finalized device. The team has failed to explain well what was done during the process.	The team has provided a description of the process used and how they understood the problem. Further, they have shown how the design philosophy and problem understanding employed resulted in the finalized device. However, they have not quite provided enough detail or context to fully understand how the process produced the final device.	Team has coherently and in detail described how the team understood the problem, who the customers were and what they wanted, and what the team design approach was. In addition, the team has drawn substantial connections between the described team approach and the finalized device, contextualized by photos and CAD models.

Assignment Outcome – 4c (i)

Prototyping, testing and post-mortem analysis – Performing a critical analysis after device prototyping of causes of success and failure

Performance Criteria • Design Process: Describe what was successfully done during the design process and what failed during the design process. Discuss successes and failures in terms of the assignment objectives and strategies. Discuss how analysis performed during designing was validated or invalidated.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
The team has either not provided both success and failures in the design process or they have focused only on one or the other. All design process involve success and failure and they have failed to explain their team’s.	The team has provided at least some successes and failures for the design process but have heavily focused on one. Further, they have failed to adequately tie them to the assignments and lectures.	The team has sufficiently described the successes and failures experienced during the design processes and have tied most to the relevant assignments and lectures. However, lacks requisite detail.	The team has provided in-depth discussion of the successes and failures of the design process employed. Further, they have thoroughly tied the given examples to the assignments and lectures.

Assignment Outcome – 4c (ii)

Prototyping, testing and post-mortem analysis – Performing a critical analysis after device prototyping of causes of success and failure

Performance Criteria • Changes to the Design Process: Address two design process issues. First, explore what changes the team could have made during the design process to rectify issues outlined in Step 2. Then, explain how these changes would have resolved the issues. Think about how the analysis could have been modified.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
The team has not described changes to the design process that could have been made or they have not shown how the changes proposed would have helped. They are lacking critical analysis.	The team has identified two key issues present in the design process but it is not clear how the provided solutions would resolve the problem. They are lacking sufficient justification or logic.	The team has identified two key issues present in their design process and have provided some methods to resolve them. The proposals sufficiently address the root issue.	The team has identified two key issues present in their design process and have proposed logical methods to resolve them. Further, they have justified the utility of the fixes in the context of the design.

Assignment Outcome – 4c (iii)

Prototyping, testing and post-mortem analysis – Performing a critical analysis after device prototyping of causes of success and failure

Performance Criteria • Design Artifact: Similar to Step 2, describe what went right with the completed device and explain what went wrong. Think in terms of the process of taking the design from the conceptual to the physical. Further, how was analysis during the prototyping phase validated or invalidated?			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
The team has either not provided both success and failures in the design artifact or they have focused only on one or the other. All prototypes involve success and failure and they have failed to explain their team’s.	The team has provided at least some successes and failures for the design artifact but have heavily focused on one. Further, they have failed to adequately tie them to the assignments and lectures.	The team has sufficiently described the successes and failures experienced during the prototyping phase and have tied most to the relevant assignments and lectures. However, lacks requisite detail.	The team has provided in-depth discussion of the successes and failures of the design artifact. Further, they have thoroughly tied the given examples to the assignments and lectures.

Assignment Outcome – 4c (iv)

Prototyping, testing and post-mortem analysis – Performing a critical analysis after device prototyping of causes of success and failure

Performance Criteria • Changes to the Design Artifact: Address two design artifact issues. First, explore what changes to the device the team could have made to improve demonstration outcomes. Second, explain why these changes could have resolved the issues identified.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
The team has not described changes to the design artifact that could have been made or they have not shown how the changes proposed would have helped. They are lacking critical analysis.	The team has identified two key issues present in the design artifact but it is not clear how the provided solutions would resolve the problem. They are lacking sufficient justification or logic.	The team has identified two key issues present in their design artifact and have provided some methods to resolve them. The proposals sufficiently address the root issue.	The team has identified two key issues present in their design artifact and have proposed logical methods to resolve them. Further, they have justified the utility of the fixes in the context of the device.

Assignment Outcome - 5b

Learning through doing, reflecting, and articulating - Articulating, using learning statements, the Principles of Engineering Design that you have internalized (team)

Performance Criteria • Learning Statements (team) – for the team, develop several learning statements pertaining to one of the target POED's for this assignment.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
Team has not provided team learning statements in any fashion	Team learning statements do not follow the learning statement structure or describe obvious, explicit learning	Team learning statements are formatted correctly and express insight but are not well connected to the POED's	Team learning statements are both insightful and tied well to the POED's. Learning expressed makes wider connections.

Assignment Outcome - 5b

Learning through doing, reflecting, and articulating - Articulating, using learning statements, the Principles of Engineering Design that you have internalized (individual)

Performance Criteria • Learning Statements (individual) – For each team member, develop several learning statements pertaining to one of the target POED's for this assignment.			
Unsatisfactory	**Developing**	**Satisfactory**	**Exemplary**
Team has not provided individual learning statements in any fashion	Individual learning statements do not follow the learning statement structure or describe obvious, explicit learning	Individual learning statements are formatted correctly and express insight but are not well connected to the POED's	Individual learning statements are both insightful and tied well to the POED's. Learning expressed makes wider connections.

ASSIGNMENT 6 EVALUATION

Grading Scheme - Components

In Assignment 6 we seek to evaluate what you have learned by reflection on doing in this course

Experience: In the grading scheme this is considered by the categories identified in which the Learning Statements are anchored. Maximum 10 points. Categories include lectures, assignments, team meetings, demonstration, etc.

Learning: In the grading scheme this is considered by the Learning Statements (written as triples) Maximum 30 points.

Value / Utility: Maximum 10 points. Takeaways (0 to 3). Learning Statements (1 to 3). Junior Engineer / Windbag (1 or 2) New POEDs (0 or 1). 5C (0 or 1).

Bonus: Maximum 5 points. Professionalism (template, numbering of Categories and Learning Statements, etc.). Name, email, section number, page number in footer. Best Practice Statements, Insightful Take Aways, etc.

Grade Calculation

Points A (50) **=** Number of Learning Statements (30) + Number of Categories (10) + Value / Utility (10)

Points B (5) = Bonus for use of template, numbering of Categories and LS, spark

Total Points (105) = 2(Points A) + Bonus Points B

Grade

ame / Section	**Points**
Number of Learning Statements (30)	
Number of Categories / Experiences (10)	
Value / Utility (10)	
Take Aways (0 to 3)	
Learning Statements (0 to 3)	
Junior Engineer / WindBag (1 or 2)	
New POED (0 or 1)	
5C (0 or 1)	
Subtotal	
Subtotal x 2	
Bonus (5)	
Template used	
Categories + LS numbered	
Spark: Takeaways / Best Practice	
Total / Grade	

Professionalism

a. Unique to this assignment: two pages MAXIMUM and NO cover page
b. 1-inch margins, Times New Roman 11-point font.
c. Submit as a Microsoft Word document. File name: AME4163_A6_YourFamilyName
d. Properly headed sections
e. Name and page numbers in footer.

ASSIGNMENT 7 GRADE RUBRIC

TEAM NUMBER / NAME

GRADE: ITEMS 1 and 7 are foundational to ITEMS 2 to 6 and 8 to 9 that are graded.

Exemplary	3
Satisfactory	2
Developing	1
Unsatisfactory	0
TOTAL	21. Maximum entered in grade sheet 7

1. Document Format and Problem Statement
a. Include a cover page with project number, project name, company sponsor, company advisors, faculty advisors, team member names, and the date b. Reproduce, verbatim, the problem statement as provided in AME4163.
Problem Statement reproduced verbatim
2. Background Information
a. Do some research into the company, including who they are, where they're located, what size of business they are, who they market to, etc. b. Research the problem. Is it a costly problem for the company? What are the safety and/or ethical concerns associated with the problem and/or its possible solution? What prior work has already been done? c. Use this as an opportunity to learn as much as possible about the company before meeting them in person.
Company Research: *Problem Research:* **Grade** Exemplary – Effort has resulted in information that is of value to requirements list and plan of action.. Satisfactory – Effort has resulted in information that may be of value to requirements list and plan of action. Developing – Information is included that is unlikely to be of use to developing requirements list or plan of action. Unsatisfactory – Just a filler.
3. Team Understanding
a. Based on the team understanding of the problem statement as provided and the background information so far explored, explain what the team understands the problem for the company to be. b. More specifically, think in terms of what value the team can provide the company. Think about whether or not they would benefit from a prototype or more involved analysis, for example.
Team Understanding of Problem: *Value Opportunity:* **Grade** Exemplary – Insight anchored in effort invested in understanding the problem. Satisfactory – Thinking evident from effort invested in understanding the problem.

Developing – Some effort to understand problem.

Unsatisfactory – Just a filler.

4. Requirements List

a. Leverage the team understanding of the problem as well as the background research performed to establish a Requirements List. This list should be as comprehensive as possible.
b. Use the Demands/Wants distinction used in the AME4163 project. Further, categorize requirements in useful ways.
c. Establish target objectives for the achievement of the requirements present on the list.

Grade

Exemplary – End of Spring Semester. Relates well to Understanding of Problem. Thinking evident.

Satisfactory – End of Spring Semester. Relates to Understanding of Problem. Good start.

Developing – Incomplete in terms of scope – only technical and limited. Focused on Fall semester.

Unsatisfactory – Just a filler.

5. Questions for Sponsor

a. Use this opportunity to establish an early relationship with the company sponsors; these are professionals using their time and experience to assist students in becoming junior engineers.
b. Questions for the sponsor should be as specific as is feasible while focusing on issues not easily researched or answerable through analysis. In other words, ask only questions that the sponsor can provide answers for.
c. Do not make the list for this assignment too exhaustive, focus on the important questions needed to start making progress as quickly as possible.

Grade

Exemplary – Good questions appropriate for a consulting team composed of Junior Engineers. Anchored in understanding of problem and requirements list

Satisfactory – Questions related to understanding of problem and requirements list

Developing – Questions – but not necessarily related to understanding of problem or requirements list

Unsatisfactory – Just a filler.

6. Plan of Action

a. Consider the remaining Fall 2019 schedule as well as the Spring 2020 schedule.
b. Discuss here the elements of the team contract and how they will be implemented.
c. Develop a Gantt chart and an expected hours breakdown for the project. This will change as you go along, but start it here.

Grade

Exemplary Anchored in understanding of problem and requirements list. Useful for Spring 2020.

Satisfactory – Somewhat related to understanding of problem and requirements list. Likely to be used in Spring 2020. Good start.

Developing – Not necessarily related to understanding of problem or requirements list. Needs much work to be useful in Spring 2030.

Unsatisfactory – Just a filler.

7. Important Milestones

a. You can find the majority of these dates in the Capstone Handbook, which will be available on Canvas.
b. Highlight dates of project deliverables.

Project Milestones:

a. Academic Calendar Events (Semester start/end dates, etc.)
b. Deliverable Deadlines (AME4553/Company Deliverables)

8. Critical Evaluation

a. Recall the various reality checks performed during the design of the AME4163 project device. Think about how the team considered ways the device could fail long before it was built.
b. Categorize the different ways the project could fail. Some examples include planning issues, scope creep, and poor communication. Think through the various possibilities and anticipate them.

Critical Evaluation of Plan of Action:
Probable Failure Modes:

Grade

Exemplary Failure modes **anchored in** key elements of Assignment 8 - understanding of problem, requirements list, plan of action, what needs to be done / known, etc.

Satisfactory – Failure modes **related to** key elements of Assignment 8 - understanding of problem, requirements list, plan of action, what needs to be done / known, etc.

Developing – Failure modes have a loose connection to key elements of Assignment 8.

Unsatisfactory – Just a filler.

9. Learning Statements

Student name …

Grade: Team and Individual

Exemplary – Triple with content, key words highlighted and insight.

Satisfactory – Triple with OK content anchored in Assignment 8.

Developing – Triple with some content – not necessarily in Assignment 8

Unsatisfactory – Not included

Professionalism

a. Team name, names of members, page number

b. Question written out then answered
c. Clarity, Connectivity, Utility
d. Spark, Insight, Extra Effort

VI. ADDITIONAL INFORMATION

CAD/FEA CFD RESOURCES AND MATERIALS

Owing to the fact that portions of the AME4163 and AME4553 courses are likely to involve computer-aided design (CAD) modeling, finite element analysis (FEA), and, potentially, computational fluid dynamics (CFD), it has been determined supplemental materials for this course should be provided which will assist the students in completion of their CAD, FEA, and CFD related tasks. In addition to the lecture slides (available on Canvas) on CAD, FEA, and CFD, several in-class examples and tutorials will be utilized this semester which will refresh student memory into the programs available on the OU College of Engineering computers. Further, the following links should provide students with further resources to explore these domains.

Computer-Aided Design

- **SolidWorks**
    - Text: http://www.solidworkstutorials.com/solidworks-user-interface/
    - Videos: http://www.solidworks.com/sw/resources/solidworks-tutorials.htm

Finite Element Analysis

- **ANSYS**
    - Videos and Text: http://www.ansys.com/Industries/Academic/Tools/Curriculum+Resources/Tutorials,+Examples+&+Curriculum
- **SolidWorks Simulation**
    - Videos and Text: http://www.solidworks.com/sw/resources/getting-started-simulation-and-analysis-tools.htm

Computational Fluid Dynamics

- **ANSYS CFX**
    - http://www.ansys.com
- **FLUENT**
    - (GAMBIT by Fluent Inc. is used for meshing): http://www.fluent.com

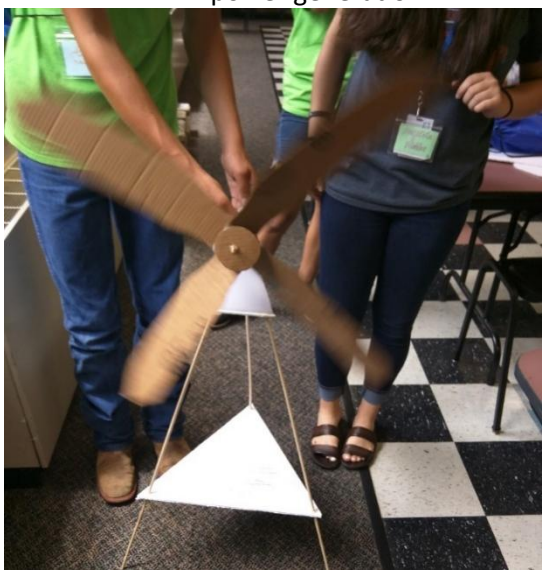
FRANKENSTEIN PROTOTYPE

During the planned prototype update in late October, teams will be expected to demonstrate their progress in the construction of their prototype. Teams who have few or no components for their actual device will be expected to provide a 'Frankenstein' prototype. A Frankenstein prototype is simply a cheap and simple physical model of your selected concept. It should not take more than an hour or two to complete and may be constructed from cheap and/or disposable materials (paper, cardboard, string, etc.). The purpose of this prototype is both to help you outline your proposed design to the instructor and give your team the chance to explore the physical geometry of your system and its constituent components. Use this as an opportunity to flesh out your selected concept. Note: a Frankenstein Prototype need not be fully functional but attempting to do so can be helpful in

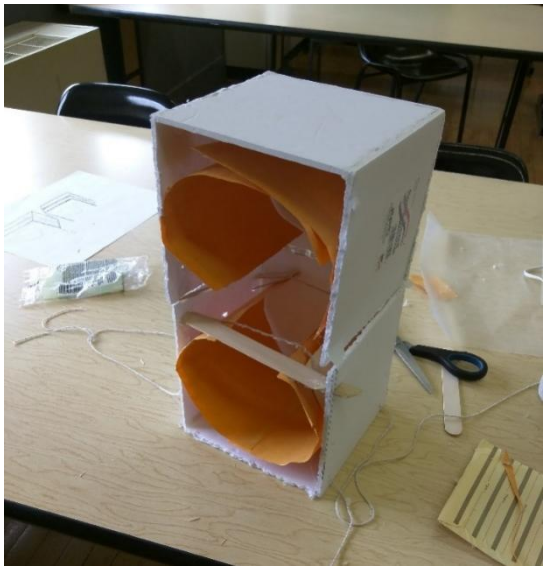
exploring component feasibility. For more information on Frankenstein Prototypes, see: http://blog.inventhelp.com/prototypes/ and http://www.precisiontype.com/producing-a-prototype-for-your-invention/

Completed Frankenstein Prototypes will resemble something like these:

Frankenstein Prototype for a portable windmill for power generation



Frankenstein Prototype for a stackable washer-dryer



DOCUMENT TEMPLATLES

In this section, we have included suggested templates for various organizational purposes. Teams are encouraged to familiarize themselves with the project progress report and meeting notes memo documents in particular, as they may come in handy in AME4553 when briefing Capstone project sponsors.

PROJECT PROGRESS REPORT FORMAT

The formatted document contained on the following page may be used by teams to keep mentors and advisors abreast of team progress and activities. Like the meeting notes template (contained in the following section), the project progress report can be used by the team to track their own progress through the semester. While not required in AME4163, they will be required in the AME4553: Design Practicum the following semester, so it is suggested that teams familiarize themselves with the document and get into the habit of preparing them.

This document can be found on Canvas under the name: AME4163_ProjectProgressReportFormat_082316.

To: *Recipients*

CC: *Relevant mentors (Professors, TA, etc.)*

From: *List senders*

Subject: *Meaningful yet short summary of subject with date included*

Planned activities for current week (from previous report and Gantt chart):

1. *List planned activities listed for the current week,*
    a. *With sub-bullets used to elaborate on project tasks*
2. *Make sure the list is readable*
3. *Make sure the numbers meaningfully reflect either the intended chronological order of completion of the tasks or their relative importance.*

Activities completed in the past week

1. *Make sure to list only those activities that have been completed since the last progress report.*
    a. *Again, elaborate with sub-bullets*

Activities not completed and actions taken to rectify

1. *List what your team was not able to accomplish that it had originally intended to. Explain why if possible and the actions taken to complete the action in a timely fashion, if necessary.*

Planned activities for the next week

1. *In this section, develop a way to stay ahead and/or on top of current activities by thinking about the next stages.*

Problems/assistance needed from mentors

1. *List questions, concerns, requests for advice, etc. for your mentors in this section. This will facilitate their advice in a more immediate fashion.*

Major Milestones to work towards

1. *If there are any relevant major events/assignments/reports/presentations/etc. coming up, then list them here.*

Appendix

In this section, be sure to include an updated Gantt chart of team activities as well as any additional material too large or not suitable for the main body of the progress report.

MEETING NOTES MEMO FORMAT

The formatted document contained here may be used by teams to document the events of weekly, bi-weekly, or randomly scheduled meetings. It encourages team organization and can be used to track team progress throughout the design process. In addition, the use of some sort of meeting record can simplify the process of completing assignments by creating a record of all events and work completed in an organized and chronological fashion. It should be noted that, unlike the project progress report document, the meeting notes memo is for internal team use only and should not usually be submitted to mentors or advisors.

This document can be found on Canvas under the name: AME4163_MeetingNotesMemoFormat_082316.

The University of Oklahoma
The School of Aerospace and Mechanical Engineering
AME 4163: Principles of Engineering Design

Form: MEETING RECORD

Group Number: **Meeting Number:** **Date:**
Location:

Members Present: 1. 2.
3.

4. 5.

Time Start_____**Time End**_____

Project Name:

Project Brief:

Agenda

Key Words:

Check off completed Items:

( ) 1. Warmup
( ) 2. Review Agenda
( ) 3. Record of Previous Meeting
( ) 4. Action item reports
( ) –
( ) –
( ) –
( ) –
( ) –
( ) –
( ) 5.
( ) 6.
( ) 7.
( ) 8.
( ) 9. Action items
( ) 10. Next meeting date, etc.
( ) 11. Meeting Summary

NOTES

Decision Roster (See next page)

Items to be considered in the future (not next meeting)

Meeting Review

+

-

Next meeting

Date **Time**

Location

Scribe

Signature

_____

Topic 5 (Brief Discussion) **Main Points**

Decisions / Conclusions

Action Items

Topic 5 (Brief Discussion) **Main Points**

Decisions / Conclusions

Action Items

Topic 5 (Brief Discussion) **Main Points**

Decisions / Conclusions

Action Items

Topic 5 (Brief Discussion) **Main Points**

Decisions / Conclusions

Action Items

MID-SEMESTER DESIGN REVIEW FORMAT

As can be seen in the schedule, in early October teams will have to present the design of their device for the project at that stage to both instructors and the TA. The students will present their selected concept and the steps they have taken to realize that concept. There will then be an opportunity for the instructors and TA to ask questions and provide advice to the student groups. In addition, each team will submit a document outlining several important components of their design. These components are outlined in the following document

This document can be found on Canvas under the name: AME4163_MidSemesterDesignReviewFormat_082316.

AME4163: Principles of Design

Mid-Semester Design Review

Project Update

[Date of presentation]

[Group number and/or nickname]

[Names of group members]

Section A: Current Pictures/Models of the Project

A. CAD Models

- Be sure to label all components of the device in the CAD model in accordance with their function and/or importance to the overall design.

B. Bill of Materials

- Students should provide a list of materials that they have bought or are preparing to purchase. This list should be specific. I.e. do not say "1 motor," say "1 Leeson Motors 24 V, 1 HP DC motor." It should also include cost, quantity, and a total cost estimate for the entire list.

C. Photographs of the device

- It is fine if at this stage all your team has are assembled materials; in such cases, photograph the materials and label the photos. If construction/assembly has begun, all the better.

Section B: What has been completed so far?

In this section, explain what has been done to realize the design. Explore how the synthesized design has come from applying the previous work done in class to this point. Explain why decisions have been made to alter or change aspects of the design and why they came about (results of testing, circumstances, cost, feasibility, etc.).

Section C: What remains to be completed?

In this section, explain to the instructors what remains to be done. This can include assembling the device, fabricating or purchasing parts, testing said device in both controlled and "field" conditions, programming (if necessary), and anything else that may be needed to complete the design. Briefly outline a schedule for the remaining activities.

Notes:

[Leave this section blank. Give room for the instructors to leave their feedback and make sure several copies of this document are printed out for both the instructors and the TA]

PROTOTYPE REVIEW FORMAT

The purpose of the prototype review, which will take place in late October, is to give the instructors a chance to provide advice regarding the prototyping and construction phase of the project. You may note that there is no assignment which specifically address the physical prototyping process. In Assignment 4, your team generates CAD models and addresses planned component selections. Following that assignment, the team then demonstrates the constructed device in front of their peers and instructors. Given this gap, we provide you this opportunity to get feedback regarding your prototyping and testing phase. At this review, we will expect to see the following:

1. Some or all components of the planned system
    a. Teams should bring any components which have been purchased and be prepared to address components which have not yet been obtained
    b. Discuss which components remain to be purchased or acquired
2. A plan for device construction and testing
    a. Be prepared to discuss how components will be utilized in the system, assembled into the finished design, and how they meet some requirement or provide some functionality to the overall system
    b. Be able to discuss a schedule for finalizing (or beginning) construction of the prototype as well as how the components will be tested
        i. Think about how components will be tested individually, as part of sub-assemblies, and as a part of the entire system
        ii. Discuss how team will account for uncertainty in the testing process (component failures, poor performance, etc.). We expect to see each team develop contingencies for likely scenarios faced.
3. Discuss a plan for performance of the system on the day of performance
    a. What components, spare parts, and/or tools does the team plan to have on hand?
    b. How is the team planning to handle problems…
        i. …On the eve of the competition?
        ii. …On the day of the competition?
        iii. …Between trials?
4. Address the roles and responsibilities of each team member as they pertain to the aforementioned items

Though no written documentation is required for this update, we encourage you to prepare some documentation of the above items both to keep your team on track and also as a reference for Assignment 5: Post-Mortem Report. In Assignment 5, we ask you to look back, after the device demonstration, to address your successes and failures and diagnose the source of both. Preparing some documentation for this review will help to plan your prototype construction and testing phase while serving as a useful source of insight in Assignment 5. Note that many of the critical points of failure for teams in previous years arose during this phase of the project; prepare accordingly.

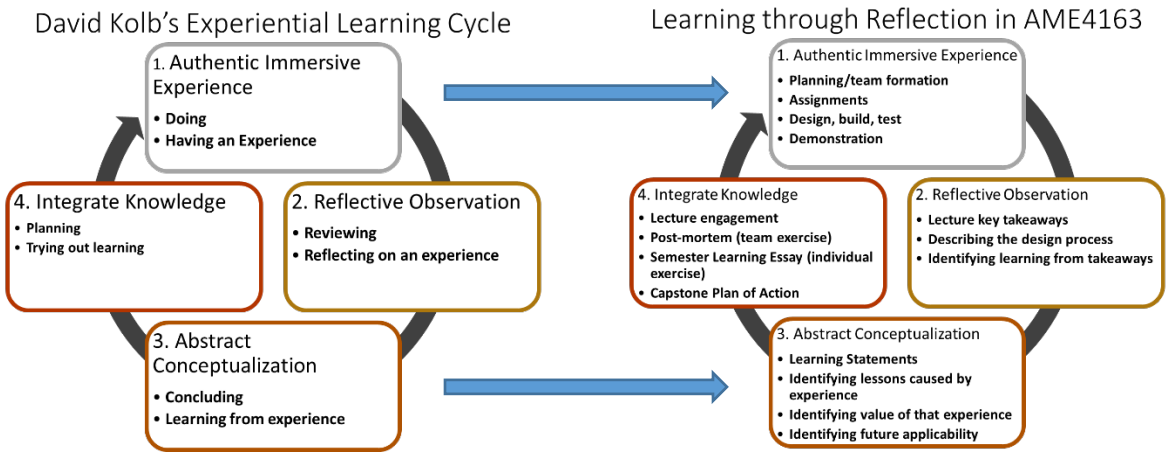
VII. READINGS

In order to assist in your learning, we also include in this booklet supplemental reading. Assigned readings for particular lectures can be found in the class schedule on Page 8. Supplemental reading is provided in order to provide additional context regarding the theoretical basis on which much of the course material is founded. Several of the following readings also provide links to additional material which may assist you in the completion of the learning exercises required in this course. Additional readings can be found on the course Canvas page in the section entitled 'Additional Readings.'

DAVID KOLB AND EXPERIENTIAL LEARNING

Source: http://cei.ust.hk/files/public/simplypsychology_kolb_learning_styles.pdf

In this course, we strive to enable junior engineers to internalize the Principles of Engineering Design by learning through reflection on doing in the context of an authentic, immersive engineering design, build, and test experience. The pedagogical basis for this approach is largely grounded in the work of an educational theorist and social psychologist named David Kolb. In 1984, he published a book on his theory of learning styles in which he detailed a model for learning in which a person learns by reflecting on experience, in contrast to other learning models such as didactic learning or rote memorization. Kolb posits that novel experiences prompt people in such a way as to challenge their preexisting knowledge. It then follows that resolution of that challenge (through reflection) results in a new model for dealing with related experiences. Kolb further asserts that the benefit of learning in this manner is that the learner is empowered to utilize the knowledge they have obtained in a wider variety of circumstances than if they had learned the same information through alternative circumstances. He called the process by which experience is transformed into learning the 'Experiential Learning Cycle,' a process which takes place in four steps. In the figure below, we demonstrate how we have modeled AME4163 on this cycle to encourage junior engineers to be cognizant and reflective participants in their own learning.



For additional context please see our papers published in the proceedings of the 2017 American Society of Engineering Education Annual Conference and Exposition.

COMMUNICATION STYLES

Source: https://www.opm.gov/policy-data-oversight/performance-management/performance-management-cycle/monitoring/communicate/

One thing we stress in AME4163 is the importance of communication in engineering design practice. Communication, in this instance, covers a wide spectrum of activities ranging from the professional presentation of work (as may be found in the assignment submissions) to the everyday discussions taking place between team members. Clear and respectful communication is essential to engineering practice and is thus another important competency we expect you to develop in this course. Given this fact, we urge you to consider reading and reflecting on the following model for communication. In particular, this model may be of use to teams consisting of members with differing communication styles, especially where those differences seem to be a source of conflict.

One nonintuitive method by which we can improve communication with others is by being an "active listener." Active listening refers to a set of practices by which a person makes an active effort to engage with material being presented to them. In a lecture context, taking notes is a form of active listening. In conversation with a team member, making a deliberate effort to think about material as it is presented to you is a form of active listening. When we communicate with others, particularly team members, it is vital that we recognize the importance of being active listeners. Communication, in a team context, necessarily exists as a back-and-forth between multiple people. This requires that we each be able to not just hear others, but to do so in such a way that we give them the space to express themselves fully while also thinking consciously about how we might respond. The United States office of Personnel Management (OPM) recommends striving to meet the following criteria to practice effective active listening:

- Take notes and plan to report on those notes.
- Concentrate on content rather than the speaker's delivery style.
- Never be afraid of silence; give speakers time to think.
- Be adept at asking encouraging questions in a positive tone.
- Summarize what the speaker has told you.

Framed this way, we consider effective communication to be the efficient transfer of information between two or more individuals. Consequently, it is not simply enough to be able to express ourselves clearly; we must do so in such a way that considers the needs of our intended recipients. To that end, the OPM also recommends thinking about the preferred communication style or styles of ourselves and others. They identify four such styles and their associated qualities thusly:

Style	Content (They talk about: . . .)	Process (They are: . . .)
Action	results, objectives, performance	down to earth, direct, impatient
Process	facts, procedures, planning	factual, systemic, logical
People	people, communication, feeling	spontaneous, warm, empathetic
Idea	concepts, possibilities, issues	imaginative, unrealistic, full of ideas

When attempting to communicate with your team members, particularly during occasions where conflict appears to be present, consider their preferred communication style as well as your own. Where are they likely to conflict? How can that conflict be bridged by modifying your own approach? Thinking about these things more consciously may provide an effective means for establishing solid communication even in the midst of difficult circumstances. In addition, consider addressing this at an early phase of the team formation process, when effective communication may be in the process of being established. In fact, consider, as an exercise, identifying each team members' preferred communication style using a quick online quiz such as this:
http://www.mit.edu/~mbarker/pmi96/commp796.txt

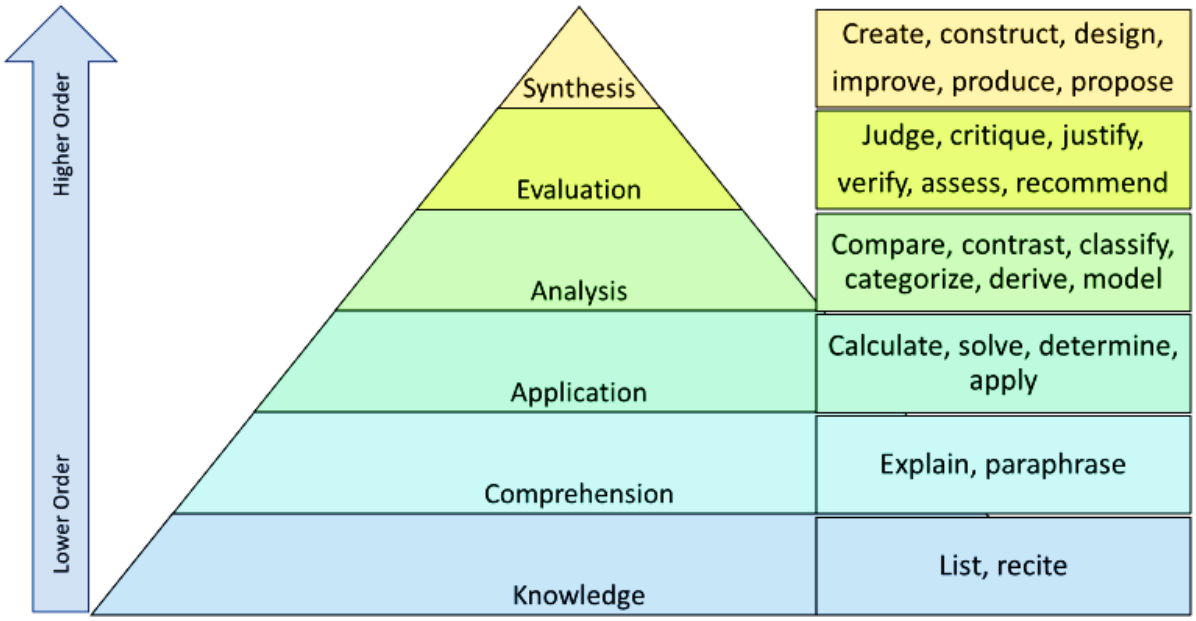
BLOOM'S TAXONOMY OF LEARNING DOMAINS

Source: https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/

Bloom's Taxonomy of Learning Domains is the name given for a construct developed by education psychologist Dr. Benjamin Bloom which outlines the steps that need to occur in order for learning beyond "rote memorization" to take place. These domains have been expanded on since the original work in the 1950's and the nomenclature contained therein serve partly as the basis for the learning statements used frequently throughout the semester. While the implications of this construct on educational science have been far-reaching and may be of interest to some students, for the purposes of the reflective exercises utilized in this course, students interested in becoming more cognizant of their learning should consider the construct on Page 60, reproduced from Vanderbilt's Center for Teaching.

Note that each domain of learning in Bloom's Taxonomy is associated with words which help to define it in greater detail. Further, in his 1956 work, Bloom identified each stage of the pyramid as being in ascending order of cognitive difficulty. Knowledge, located at the bottom of the figure, is considered the starting point for more complex cognitive activities. Essentially, we start with some basic amount of knowledge known simply to us as a set of facts or observations. Moving up the pyramid, we move into comprehension by understanding the knowledge well enough to communicate it to others. Following that, we then begin to identify how that knowledge can be used to address some issue. In the Analysis domain, we expand on the Application domain by generating new information. Stepping into the Evaluation domain, we then begin to evaluate the knowledge that we have generated. Finally, in the Synthesis domain, we can use our conclusions to take actionable steps to put our newfound conclusions into practice. Each stage of Bloom's Taxonomy corresponds to some level of evolution in how we grow in our learning. We can see that this model can be used to interpret our learning both in the short-term (our learning in a particular course) as well as the long-term, such as how you are expected to grow as an engineer from a freshman studying simple physics and calculus to a senior solving open-ended, contextual design, build, and test problems.

Bloom's Taxonomy



LEARNING STATEMENTS

In each assignment and at the conclusion of all course lectures, each junior engineer is tasked with writing learning statements. Learning statements are a way for you to reflect on your experiences and identify key lessons learned. In particular, we are asking you to demonstrate that you are both internalizing the target POED and formulating an understanding of how you can apply this knowledge moving forward (both in your education and your later careers). We insist on the following format for learning statements:

Structure of the Learning Statement

Experience x	**Learning y**	**Value/Utility z**
Through **x** (From **x**, By doing **x**, …)	I learned **y**	
I did not consider **x** initially	I realized **y**	Value/Utility **z**
I thought (expected) **x** before/initially	I found out **y**	in future of
	I discovered **y**	learning **y**
	I became conscious of **y**	
Value (Lectures) = Help you transition from a student to a junior engineer + gain insight into how to do the assignments		
Value (Assignments) = Principles of Engineering Design		

Learning statements take the form of statements which begin with a clause describing the event or activity in which learning took place and end with a description of the learning using action words taken from Bloom's taxonomy (see the Bloom's Taxonomy figure). These action words help to assist you in being deliberate in your analysis of your learning. When constructing learning statements, endeavor to demonstrate learning of more than mere technical skills. So-called "low-hanging fruit" is NOT of interest to the instructors and will be graded more harshly. Instead, try to analyze your learning in more abstract or complex domains. Consider the following example learning statement, in which a student from Fall 2016 describes a student's experience with team formation.

Example

*"**Before** this assignment, I did not consider forming a team to be much more than assembling a group of random individuals, but **after** experiencing it first-hand **I have realized** that it involves learning about others' identities, aspirations, and skills to form a team that will be both diverse and successful and the **value** of this realization is that it will help me form successful teams in the future."*

- Fall 2016 AME4163 Student

The format is strong and the insight is decent but the 'value' portion of the statement is lacking in specificity. Do not simply say that a particular lesson will be valuable in the future, describe in what way it will be valuable in the future. Throughout the course, we will generally evaluate learning statements on a scale from zero to three points. Zero points will be given to statements in which the format is not correct. One point will be given to statements in which the learning described is trivial (low-hanging fruit) or obvious to the experience (see relevant lectures for examples). Two points will be awarded to statements which demonstrate some connection to POEDs or future practice but where that connection is tenuous or vague. Three points will be given to statements in which the junior engineer has developed insight (demonstrate internalization of POEDs or wider application of learning to future endeavors).

If you are interested in a more thorough exploration of the role of learning statements as an educational and research tool, the instructors of AME4163 have produced some papers which can be found in the proceedings of both the 2016 and 2017 American Society of Engineering Education Annual Conference and Exposition (See the citations in the readings section on David Kolb on Page 57).

COMPETENCIES

Competencies are defined as the skills or critical attributes required to be successful in a given field or subject. Competencies can be technical skills or more 'meta' skills (such as the ability to manage new information) which together are important for engineering development. The targeted competencies for this course are based in large part on those recommended by Lucas Balmer in his 2015 Master's Thesis. In turn, the competencies outlined in his work are in large part based on the recommendations of the ABET accreditation board as well as those competencies which surveys of industries have revealed are the competencies that companies most desire in their straight-out-of-school engineering hires. Recall from Page 1 of the course booklet that the target competencies for AME4163 are as follows:

1. The ability to learn by reflecting on doing
2. The ability to speculate on future trends and pose useful questions for future investigation
3. The ability to make engineering design decisions in the face of limited information
4. The ability to adapt to new circumstances such as a new design team or problem
5. The ability to introspectively self-assess to improve as a designer

Acquisition of these target competencies will enable you to transition into and succeed in your Capstone projects (AME4553) and later into your first engineering positions. They will become extremely relevant as you begin work on Assignment 8, your Capstone plan of action.

Mechanical Engineering Diversity and Inclusion Training

DEVELOPED AND HOSTED BY LAVONYA BENNETT

SEPTEMBER 4 AND 6 OF 2018

Brief References

- Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52*(6), 613-629. doi:10.1037/0003-066x.52.6.613
- Gaertner, S. L., & Dovidio, J. F. (1986). *The aversive form of racism*. Academic Press.
- Roberson, Q. M. (2006). Disentangling the meanings of diversity and inclusion in organizations. *Group & Organization Management*, *31*(2), 212-236.

Contact LaVonya Bennett

I would love to partner with you or your organization to facilitate, develop, or host a diversity and inclusion training, seminar, conference, or webinar. For further details on availability and pricing please contact me directly via phone or email.

Email: lavonyabennett@ou.edu or lavonyabennett@gmail.com

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Overview of Training

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- Opening
- Workforce Dialogue
- Engaging Behaviors
- Stereotype Threat
- Aversive Racism
- Terms of Conflict

Day 2

- Recap
- Managing Conflict
- Social Identity
- Case Studies
- Closing

Need for Diversity and Inclusion in ME

Understanding Terms

Diversity can be conceptualized as a numerical trait. Inclusion can be conceptualized as an action of appreciation, learning, and welcoming environments for diversity.

"Diversity is having a seat at the executive table. Inclusion is having the opportunity to be an equitable, contributing, and appreciated member while at the table"

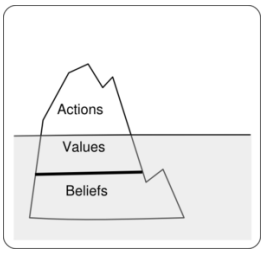
Results of Diverse in Inclusive Practices:

Diversity/Cultural Competency are one factor for obtaining and maintaining accreditation in Mechanical Engineering programs.

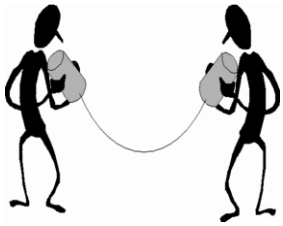
- Increased innovation
- Quality customer service
- Cohesive collaboration

Theory to Practice

Engaging Behaviors



When we meet or work with another person, we get a small glimpse of their beliefs, values, attitudes, experiences, and social identities. People are similar to icebergs, there are much more complex attributes beyond the surface. Some people are comfortable sharing openly and some people are reserved. Some people may vary depending on the environment they are in.



Appropriate verbal and not verbal behaviors vary across culture. Below you can outline appropriate verbal and non-verbal ways to engage with others. Remember, your engagement style should be fluid and malleable to your audience.

-
-
-
-
-
-
-

Terms of Conflict

Several factors, including lack of cultural awareness and empathy, stereotype threat, and aversive racism can inflate the likelihood of experiencing conflict when working with others.

You should always make it a priority to become culturally competent. Not only with this aid in the reduction conflict, but it will increase productivity and innovation.

Stereotype Threat

Stereotype threat is the phenomenon in which a person believes they may be at risk of conforming to a stereotype about their social group.

Stereotype threat can negatively impact the cognitions of an individual and have profound effects on their behavior.

Aversive Racism

Aversive racism is when people regard themselves as non- prejudice and often have consuming thoughts about being labeled as racist.

Aversive racism can negatively impact positive interactions, self-reflection, and celebration of differences.

NOTES PAGE

APPENDIX.B THE USER-MENU OF THE TEXT MINING PROGRAM

1. The Interfaces of the Text Mining Program

There are two user interfaces of the text mining program for users to operate. By clicking the top menu in the program, the interfaces can be changed as needed in figure 1.

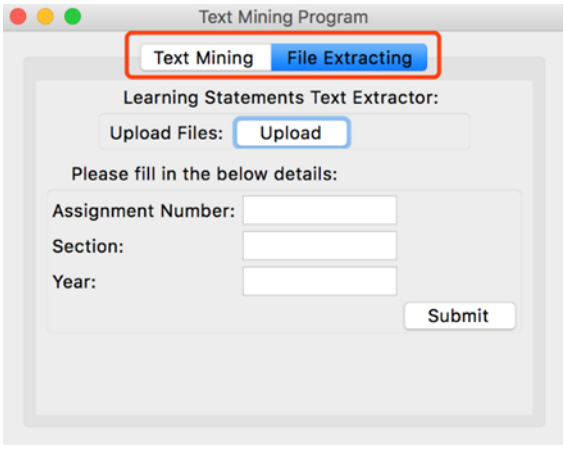


Figure 1 Interface Changing Menu

When users click the tab: 'File Extracting', the interface is the text extraction interface as shown in figure 2. When users click the other tab: 'Text Mining', the interface will be changed to the visualization interface as shown in figure 4.

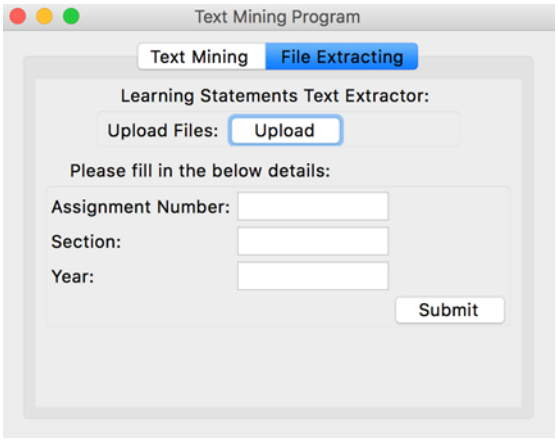


Figure 2 The Text Extraction Interface

There are two parts in the text extraction interface as shown in figure 3. The upper part is the uploading function for users to upload the textual documents and the lower part is the inputting rows for users to add the corresponding attributes of the textual documents. Users can upload the original documents into the program in the upper part and add the associated attributes of the text documents in the lower part. When users click the button: 'Submit', the program executes the data extraction and data storage functions to save the cleaned data and the associated attributes into the schemed database.

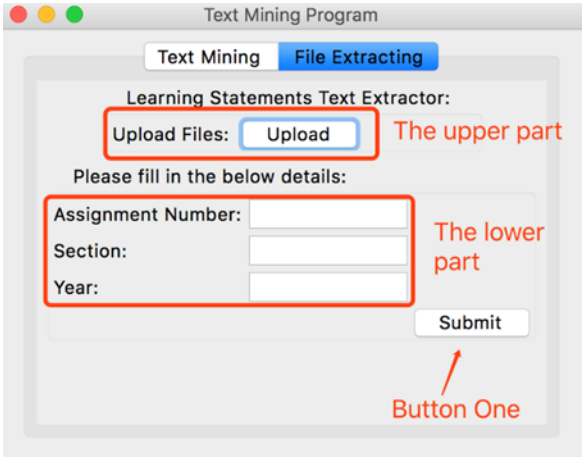


Figure 3 The Description in the Text Extraction Interface

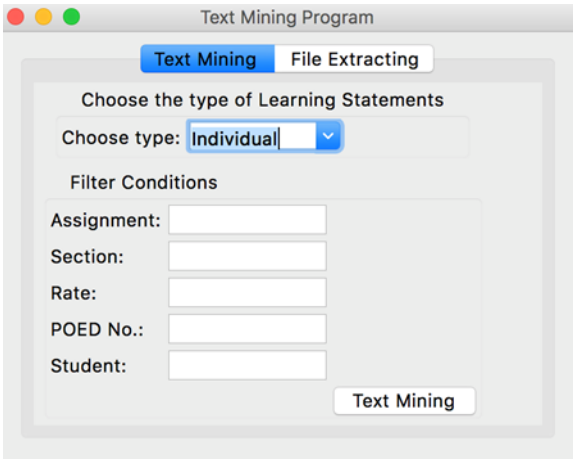


Figure 4 The Visualization Interface

In the visualization interface, users can get the visualization results of the word frequency histogram and word cloud by screening data with the filter conditions from the database of the program as shown in figure 5. When users click the button: 'Text Mining', the program obtains the matched text contents from the schemed database, uses the corresponding algorithm to compute the selected text contents, and finally shows the visualization results to users.

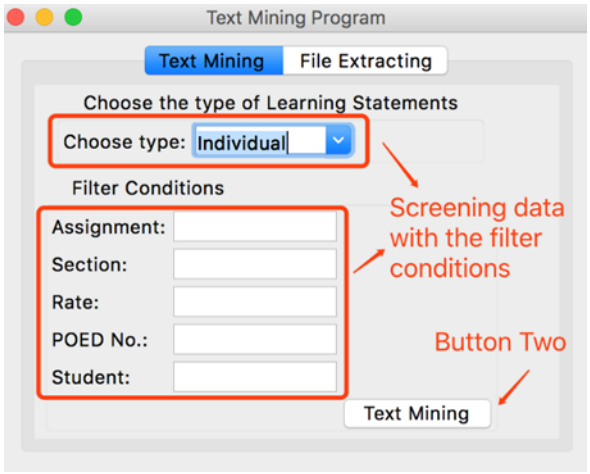
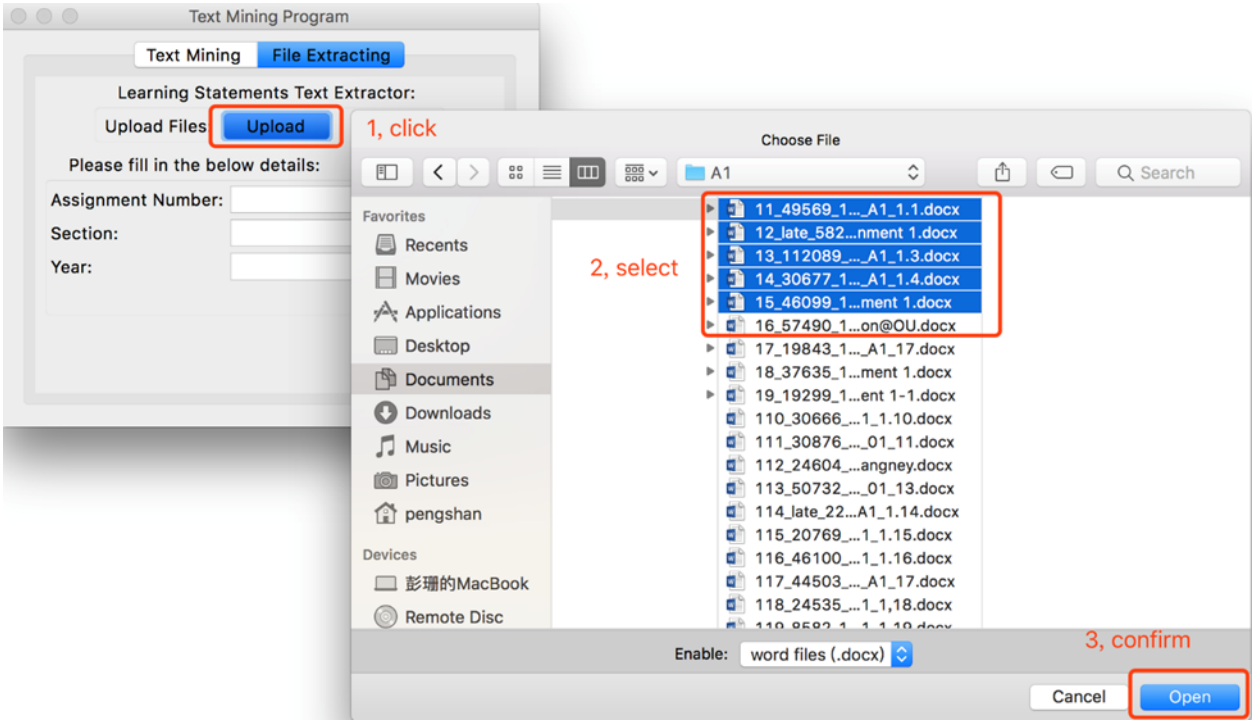


Figure 5 The Description in the Visualization Interface

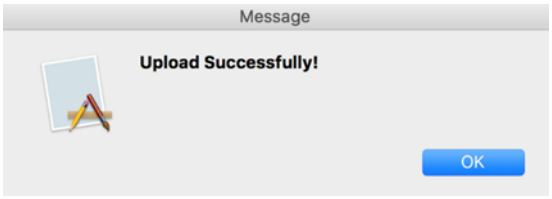
2. The Steps in Interface 1: The Text Extraction Interface

In the text extraction interface, there are three steps to operate as bellows:

Step 1: Uploading the textual documents

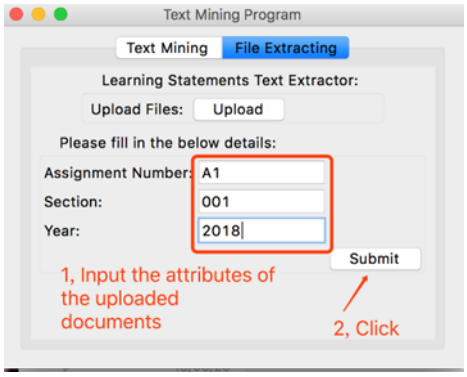


Firstly, users can click the button: 'Upload'. And then in the pop-up window: 'Choose File', users choose the necessary textual documents for analyzing. The uploaded documents can be selected more than one item. Finally, users click the button: 'Open' to confirm the uploaded documents. The program will pop up a new message window to remind users that the uploading operation is successful.



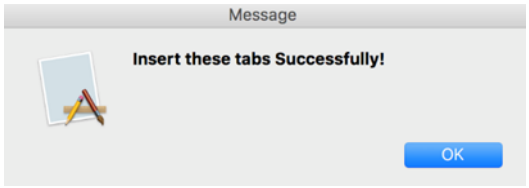
Step2: Inputting the attributes for the textual documents

After uploaded the textual documents, the second step for users is inputting the corresponding attributes for these documents. The attributes include assignment number, section and year. The other attributes like student's name, team and date can be collected in the textual documents.



Step3: Clicking the button: 'Submit'

When users click the button: 'Submit', the program will pop up a new message window to remind users that the attributes are inserted successful and saved into the database.

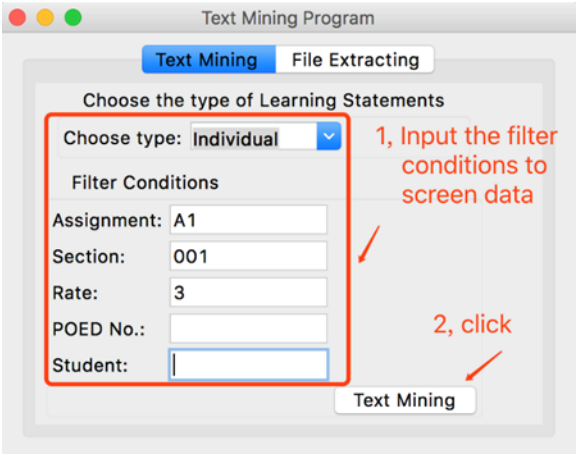


3. The Steps in Interface 2: The Visualization Interface

In the text extraction interface, there are two steps to operate as bellows:

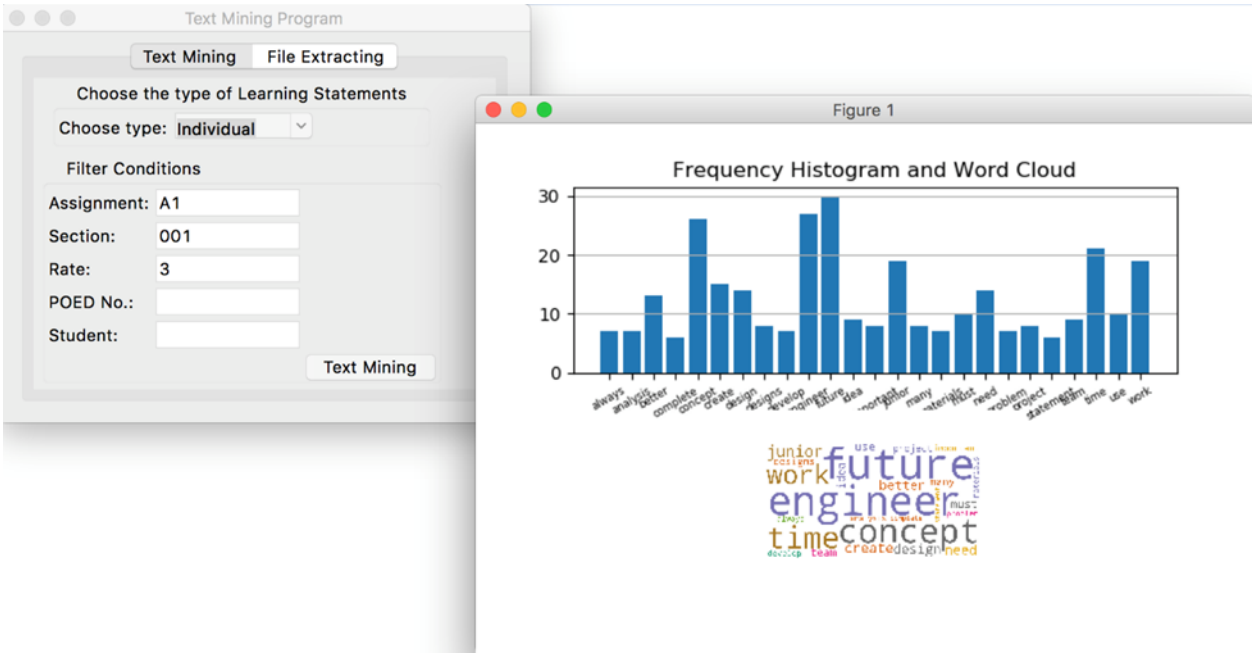
Step 1: Screening data with the input conditions

In the visualization interface, users select the type of data and input the filter conditions to screen data. There are two types in the program: individual and team. The conditions include assignment, section, rate, poed and student's name. The conditions can be inputted as required. If there is not any condition to input, the program will analyze the whole data in the database to compute and visualize.



Step 2: Visualizing the text mining results

When users click the button: 'Text Mining', the program will obtain the matched data from the schemed database, and then compute the text mining results with the appropriate algorithm. Finally, the program shows the visualization result as below:



4. The Workflow of the Program

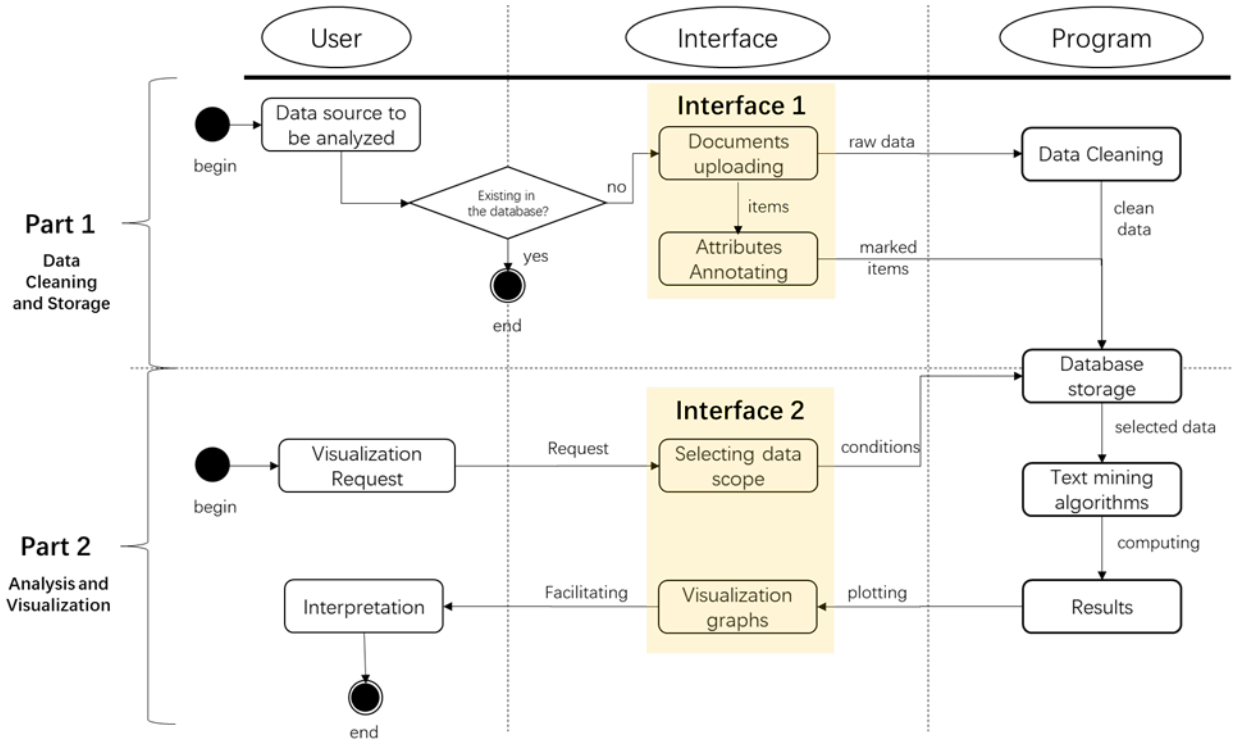


Figure 6 Execution Workflow of the Text Mining Program

Figure 6 is the execution workflow of the text mining program. The execution workflow comprises of two parts: Part 1 is data cleaning and storage, as shown in the upper row of figure 6; Part 2 is analysis and visualization, as shown in the lower row of figure 6. There are three objects involved in the workflow: user, interface, and program. In Part 1, a user begins with data source to be analyzed. If the data source exists in the database, the execution of Part 1 ends, otherwise the user uploads the original textual documents to the program in Interface 1, and annotate these uploaded documents using related attributes. By executing the data cleaning functionality, the text mining program transform the raw data in the uploaded documents into the clean data, and then save the clean data to the database with related attributes. In Part 2, a user begins with a visualization request. Based on the request, the user select the data scope in Interface 2. The selected data scope then generates the corresponding searching conditions in the database, with which the program can obtain the matched data and feed this data to text mining algorithms for computing. The computing results are sent back to Interface 2 for plotting. The plotted visualization graphs are used to facilitate the user gaining insights about the text contents.

APPENDIX.C THE HANDBOOK OF THE TEXT MINING PROGRAM

The workflow for installing the text mining program

For installing the text mining program, there are developing environments that needs to be installed first. The environments include Python and MySQL which are open source. Python is the developing language to develop and compile the code. With the code in Python, the data of learning statement can be extracted the key components and saved into the database. The text mining and visualization methods can be realized with Python. MySQL is a software to store the data with relational structure. In the tables of MySQL, there are abundant information to relate the original text learning statements. With developing in Python and MySQL, the text mining program can be used to analyze students' learning statement and generate many visualization results. In the following sections, I will detailed introduce the way to install the relevant software. In this section, I will present the workflow for installing the text mining program entirely.

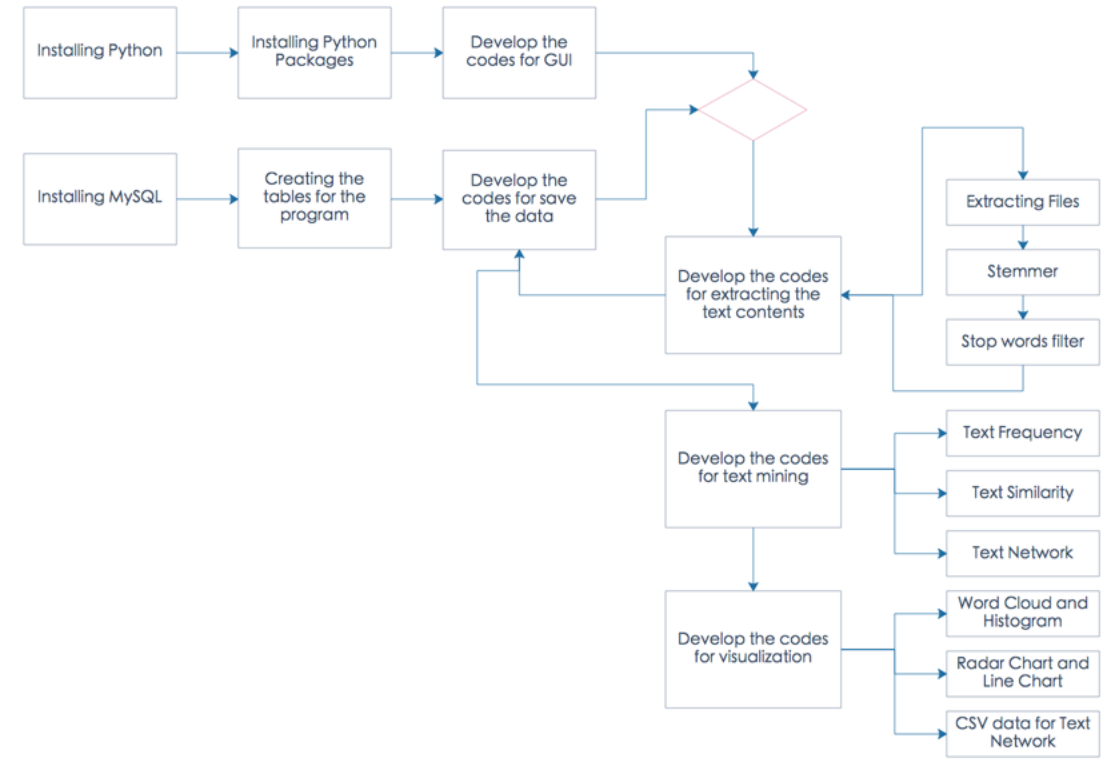


Figure 1 The workflow for installing the text mining program

The packages for Python to install

For installing the development language of Python, the official website is https://www.python.org/. Through the website, the installation packages can be downloaded and many corresponding development tutorials can be found. Generally, the latest version of Python is the best choice, and my version of Python for the text mining program is Python 3.6.5.

There are a lot of additional module libs which need to install for invoking different methods in Python. The command line is

pip install sys(the libs)

The required libs for the text mining program are

tkinter docx re mysql datetime nltk os glob matplotlib wordcloud

```
import tkinter as tk
import tkinter.messagebox as msg
from tkinter import PhotoImage
from tkinter import ttk
from tkinter import scrolledtext
from tkinter import Menu
import tkinter.filedialog as fd
```

```
import docx
import re
from guiFunction import MySQL

from datetime import date
import nltk
from nltk import word_tokenize
from nltk.corpus import stopwords

import sys
from os import path
import glob
# from pylab import *
import matplotlib as mpl
mpl.use('TkAgg')
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
from wordcloud import WordCloud
from wordcloud import ImageColorGenerator
```

How to install SQL for the program?

For installing the database software of MySQL, the official website is https://www.mysql.com/. There is the latest version of installation package and handbook to use. Generally, the latest version of MySQL is the best choice, and my version of MySQL for the text mining program is MySQl 1.3.13. When installing the software, there is some information which needs to provide, such as username, password and port, and these information can be default. If Python and MySQL are all installed successfully, then the connection can be tested to verify. Below are the test codes.

```
import mysql.connector as mysql
class MySQL():
   # class variable
   GUIDB  = 'GuiDB'

   #-----------------------------------------------------
   def connect(self):
      # connect by unpacking dictionary credentials
      conn = mysql.connect(user='root',password='Farrokh1945',host='localhost')
```

```
    # create cursor
    cursor = conn.cursor()

    return conn, cursor
```

The SQL table

There are two tables in the database. The first one is Individual_Learning_Statements, and the second one is Team_Learning_Statements. The first table is used to store students' individual learning statements and the attributes of the individual table include students' information, assignment and POED. The second table is used to store team's learning statements. The attributes of the second table include team's information. Below are two tables' structure.

Table: Individual_Learning_Statements

Attribute	Type	Explanation
StudentName	Varchar(100)	Captures the student Name
StudentId	Integer	Captures the student ID.
Semester	Char(20)	Captures the semester to which the learning statement belongs, for example, Fall2018, Fall2019, etc.
Section	Char(20)	Captures the grade given by the instructor or teaching assistant in terms of the student's performance in the assignment.
Assignment	Char(20)	Captures the assignment from which the learning statement was generated, for example, Assignment 1 (Team Formation), Assignment 2 (Conceptual Design), etc.
POED	Chart(20)	The corresponding POED which students mark in assignments.
Rate	Integer	The rate's results which come from instructors and TA.
TeamNumber	Char(20)	Captures the team number
OriginalLS	Varchar(1000)	Captures the original learning statement before it is cleaned.
CleanKeyComponents	Varchar(500)	Captures the key components of the learning statement after it is cleaned.
Grade	Double	Captures the grade given by the instructor or teaching assistant in terms of the student's performance in the assignment.

Table: Team_Learning_Statements

Attribute	Type	Explanation

TeamNumber	Char(20)	Captures the team number
Semester	Char(20)	Captures the semester to which the learning statement belongs, for example, Fall2018, Fall2019, etc.
Section	Char(20)	Captures the grade given by the instructor or teaching assistant in terms of the student's performance in the assignment.
Assignment	Char(20)	Captures the assignment from which the learning statement was generated, for example, Assignment 1 (Team Formation), Assignment 2 (Conceptual Design), etc.
POED	Chart(20)	The corresponding POED which students mark in assignments.
Rate	Integer	The rate's results which come from instructors and TA.
OriginalLS	Varchar(1000)	Captures the original learning statement before it is cleaned.
CleanKeyComponents	Varchar(500)	Captures the key components of the learning statement after it is cleaned.
Grade	Double	Captures the grade given by the instructor or teaching assistant in terms of the student's performance in the assignment.

The codes for the text mining program

GUI

```
'''
Created on Nov 11, 2018
@author: shan.peng@ou.edu
'''

import tkinter as tk
import tkinter.messagebox as msg
from tkinter import PhotoImage
from tkinter import ttk
from tkinter import scrolledtext
from tkinter import Menu
import tkinter.filedialog as fd
import docx
import re
from guiFunction import MySQL
```

```
from datetime import date
import nltk
from nltk import word_tokenize
from nltk.corpus import stopwords

import sys
from os import path
import glob
# from pylab import *
import matplotlib as mpl
mpl.use('TkAgg')
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
from wordcloud import WordCloud
from wordcloud import ImageColorGenerator


class OOP():
    def __init__(self):
        self.win = tk.Tk()
        self.win.title("Text Mining Program")
        self.createWidgets()
        # create MySQL instance
        self.mySQL = MySQL()

    def Upload(self):
        print('upload')
        self.mySQL.deleteIndividualLSs()
        # Choose File
        selectFileNames = fd.askopenfilenames(title='Choose File',filetypes=[('word
files', ('docx'))])
        #print(selectFileNames)
        joinstr = "\n"
        for selectFileName in selectFileNames:
            i = 1
            date, team_number, last_name, first_name = '', '', '', ''
            textfile=docx.Document(selectFileName)
            for texttable in textfile.tables:
                continue
                for row_number, textrow in enumerate(texttable.rows):
                    for textcell in textrow.cells:
                        if i == 1:
                            names = textcell.text.split(' ')
                            first_name = names[0]
                            last_name = names[-1]
                        if i == 2:
                            team_number = re.findall(r"(\d+\.\d+)", textcell.text)[0]
                        if i == 4:
```

```
                date = textcell.text

            i += 1
    # print(first_name, last_name, team_number, date)
    learningpoed, learningtext = {}, {}
    learningstatement = []
    j=0
    for textpart in textfile.paragraphs:
        textstr = ''
        new_textstr = ''
        if textpart.style.name.startswith('Heading'):
            continue
        if textpart.text:
            textstr = textpart.text
            new_textstr = textstr.replace("'",'')
            if ':' in new_textstr:
                textarr = new_textstr.split(':')
                if len(textarr[1]) > 15:
                    learningpoed[j] = 'poed'
                else:
                    learningpoed[j] = textarr[0]
                learningtext[j] = textarr[-1]
                learningstatement.append(textarr[-1])
            else:
                learningpoed[j] = 'poed'
                learningtext[j] = new_textstr
                learningstatement.append(textarr[-1])
        j += 1
    learninginfo = joinstr.join(learningstatement)
    f = open("new19A6002.txt","a+")
    f.write(learninginfo)
    f.close()

    '''
    # insert learning state into sql
    sql_inserts = []
    sql_insert_str = ''
    for key in learningpoed:
        # change into database
        name = first_name + ' ' + last_name
        ouid = 'id***'
        poed = learningpoed[key]
        rate_num = '3'
        assignment = 'A6'
        dtime = date
        teamnum = team_number
        learning_info = learningtext[key]
```

```
            insert_str = "('" + name + "','" + ouid + "','" + poed + "','" \
            + rate_num + "','" + assignment + "','" + dtime + "','" + teamnum +
"','" +\
            learning_info + "')"
            sql_inserts.append(insert_str)
            # change to the str
            # insert into database
            sql_insert_str = ",".join(sql_inserts)
            # self.mySQL.createGuiDB()
            # self.mySQL.createTables()
         # self.mySQL.insertIndividualLSs(sql_insert_str)
         print(sql_insert_str)
         '''
      msg.showinfo("Message","Upload Successfully!")

   def Download(self):
      select_infos = {"Rating":"3"}
      results = self.mySQL.selectIndivudualLSs(select_infos)
      for result in results:
         print(result)
         break
      msg.showinfo("Message","Insert these tabs Successfully!")

   def TextMining(self):
      d = path.dirname(path.realpath(__file__))
      back_coloring = mpimg.imread(path.join(d,"oblong.jpeg"))
      select_infos = {"Rating":"3"}
      results = self.mySQL.selectIndivudualLSs(select_infos)
      print(results)
      stemmerFile = open('miningStemmer.txt','r')
      stemmerlines = stemmerFile.readlines()
      stemmer_words = {}
      for sline in stemmerlines:
         new_sline = sline.replace('\n','')
         sline_arr = new_sline.split(":")
         stemmer_ori = sline_arr[0]
         stemmer_res = sline_arr[1]
         stemmer_words[stemmer_ori] = stemmer_res
      stop_words = set(stopwords.words('english'))
      unique_words = ['','1','2','3','4','5',' ','learn','help','value',
'assignment']
      stop_words.update(unique_words)
      ori_word_arr = []
      new_word_arr = []
      for result in results:
         new_oriline = ''.join(result)
         new_oriline2 = new_oriline.replace("â€™",'')
```

```
            new_oriline3 = new_oriline2.replace("â€œ",'')
            new_oriline4 = new_oriline3.replace(',','')
            new_oriline5 = new_oriline4.replace('.','')
            new_oriline6 = new_oriline5.replace('/','')
            new_oriline7 = new_oriline6.lower()
            ori_word_arr = new_oriline7.split(" ")
            for ori_word in ori_word_arr:
                new_word = self.stemmerFunc(ori_word,stemmer_words)
                if new_word not in stop_words:
                    new_show_word = new_word
                    new_word_arr.append(new_show_word)
        # the whole word array
        fdist = nltk.FreqDist(new_word_arr)
        frenquency_words = dict(fdist.most_common(25))
        print(frenquency_words)
        plt.figure(figsize=(10, 6))
        ax1 = plt.subplot(2,1,1)
        ax2 = plt.subplot(2,1,2)
        x_arr = []
        y_arr = []
        for fren_key in sorted(frenquency_words.keys()):
            x_arr.append(fren_key)
            y_arr.append(frenquency_words[fren_key])
        plt.sca(ax1)
        plt.title('Frequency Histogram and Word Cloud')
        plt.grid(axis="y")
        plt.bar(x_arr,y_arr)
        plt.xticks(rotation=30,fontsize=6)

        wc = WordCloud(
            mode='RGBA',
            colormap='Dark2_r',
            background_color="white",
            mask=back_coloring,
            max_font_size=150,
            random_state=42,
            prefer_horizontal=0.8
            )
        wc.generate_from_frequencies(frequencies=frenquency_words)

        image_colors = ImageColorGenerator(back_coloring)
        plt.sca(ax2)
        # show word cloud
        plt.imshow(wc)
        plt.axis("off")
        plt.show()
```

```
    def stemmerFunc(self, single_word, stemmer_word_arr):
        key_bool = stemmer_word_arr.__contains__(single_word)
        if(key_bool):
            new_word = stemmer_word_arr[single_word]
        else:
            new_word = single_word
        return new_word

    def createWidgets(self):
        photo_ou =
PhotoImage(format='png',file=r"/Users/pengshan/py/IndivLSsubsets/logo.png")
        photo_srl =
PhotoImage(format='png',file=r"/Users/pengshan/py/IndivLSsubsets/SRL-Logo.png")
        imageLabel = ttk.Label(self.win, image=photo_srl)
        # imageLabel.pack()
        tabControl = ttk.Notebook(self.win)
        tab2 = ttk.Frame(tabControl)
        tabControl.add(tab2, text='Text Preprocessing')
        tab1 = ttk.Frame(tabControl)
        tabControl.add(tab1, text='Text Analysis')
        tabControl.pack(expand=1, fill="both")

        self.monty = ttk.LabelFrame(tab1, text=' Choose the type of Learning
Statements')
        self.monty.grid(column=0, row=3, padx=8, pady=4)

        ttk.Label(self.monty, text="Choose type:").grid(column=0, row=3)
        number = tk.StringVar()
        numberChosen = ttk.Combobox(self.monty, width=10, textvariable=number)
        numberChosen['values'] = ('Individual','Team')
        numberChosen.grid(column=1, row=3)
        numberChosen.current(0)
        '''
        ttk.Label(self.monty, text="File Path:").grid(column=0, row=1, sticky='W')
        filePath = tk.StringVar()
        pathEntered = ttk.Entry(self.monty, width=12, textvariable=filePath)
        pathEntered.grid(column=1, row=1, sticky='W')
        '''


        self.monty2 = ttk.LabelFrame(tab1, text=' Field Condition: ')
        self.monty2.grid(column=0, row=7, padx=8, pady=4)

        ttk.Label(self.monty2, text="Semester:").grid(column=0, row=8, sticky='W')
        year = tk.StringVar()
        assignmentEntered = ttk.Entry(self.monty2, width=12, textvariable=year)
        assignmentEntered.grid(column=1, row=8, sticky='W')
```

```
        ttk.Label(self.monty2, text="Section:").grid(column=0, row=9, sticky='W')
        section = tk.StringVar()
        sectionEntered = ttk.Entry(self.monty2, width=12, textvariable=section)
        sectionEntered.grid(column=1, row=9, sticky='W')

        ttk.Label(self.monty2, text="Assignment:").grid(column=0, row=10, sticky='W')
        assignment = tk.StringVar()
        assignmentEntered = ttk.Entry(self.monty2, width=12, textvariable=assignment)
        assignmentEntered.grid(column=1, row=10, sticky='W')

        ttk.Label(self.monty2, text="POED:").grid(column=0, row=11, sticky='W')
        spoed = tk.StringVar()
        srateEntered = ttk.Entry(self.monty2, width=12, textvariable=spoed)
        srateEntered.grid(column=1, row=11, sticky='W')

        ttk.Label(self.monty2, text="Grade:").grid(column=0, row=12, sticky='W')
        srate = tk.StringVar()
        srateEntered = ttk.Entry(self.monty2, width=12, textvariable=srate)
        srateEntered.grid(column=1, row=12, sticky='W')

        #ttk.Label(self.monty2, text="Student:").grid(column=0, row=12, sticky='W')
        #student = tk.StringVar()
        #studentEntered = ttk.Entry(self.monty2, width=12, textvariable=student)
        #studentEntered.grid(column=1, row=12, sticky='W')

        self.action2 = ttk.Button(self.monty2, text="Text
Mining",command=self.TextMining)
        self.action2.grid(column=2, row=13)

        self.monty3 = ttk.LabelFrame(tab2, text=' 1) upload original documents ')
        self.monty3.grid(column=0, row=1, padx=8, pady=4)

        ttk.Label(self.monty3, text=" Upload action: ").grid(column=0, row=2)
        self.action_extract = ttk.Button(self.monty3,
text="Upload",command=self.Upload)
        self.action_extract.grid(column=2, row=2)

        self.monty4 = ttk.LabelFrame(tab2, text=' 2) fill the associated attributes')
        self.monty4.grid(column=0, row=6, padx=8, pady=4)


        ttk.Label(self.monty4, text="Semester:").grid(column=0, row=7, sticky='W')
        year_extract = tk.StringVar()
        yearExtract = ttk.Entry(self.monty4, width=12, textvariable=year_extract)
        yearExtract.grid(column=1, row=7, sticky='W')

        ttk.Label(self.monty4, text="Section:").grid(column=0, row=8, sticky='W')
```

```
        section_extract = tk.StringVar()
        sectionExtract = ttk.Entry(self.monty4, width=12,
textvariable=section_extract)
        sectionExtract.grid(column=1, row=8, sticky='W')

        ttk.Label(self.monty4, text="Assignment:").grid(column=0, row=9, sticky='W')
        ass_num = tk.StringVar()
        assNumEntered = ttk.Entry(self.monty4, width=12, textvariable=ass_num)
        assNumEntered.grid(column=1, row=9, sticky='W')


        self.action_submit = ttk.Button(self.monty4,
text="Submit",command=self.Download)
        self.action_submit.grid(column=2, row=10)

        menuBar = Menu(tab1)
        self.win.config(menu=menuBar)
        fileMenu = Menu(menuBar, tearoff=0)
        menuBar.add_cascade(label="File", menu=fileMenu)
        helpMenu = Menu(menuBar, tearoff=0)
        menuBar.add_cascade(label="Help", menu=helpMenu)

        # nameEntered.focus()
#=========================
oop = OOP()
oop.win.mainloop()
```

SQL

```
import mysql.connector as mysql
class MySQL():
    # class variable
    GUIDB  = 'GuiDB'

    #------------------------------------------------------
    def connect(self):
        # connect by unpacking dictionary credentials
        conn = mysql.connect(user='root',password='Farrokh1945',host='localhost')

        # create cursor
        cursor = conn.cursor()

        return conn, cursor
```

```
    #-----------------------------------------------------
    def close(self, cursor, conn):
        # close cursor
        cursor.close()

        # close connection to MySQL
        conn.close()

    #-----------------------------------------------------
    def showDBs(self):
        # connect to MySQL
        conn, cursor = self.connect()

        # print results
        cursor.execute("SHOW DATABASES")
        print(cursor)
        print(cursor.fetchall())

        # close cursor and connection
        self.close(cursor, conn)

    #-----------------------------------------------------
    def createGuiDB(self):
        # connect to MySQL
        conn, cursor = self.connect()

        try:
            cursor.execute(
                "CREATE DATABASE {} DEFAULT CHARACTER SET 'utf8'".format(MySQL.GUIDB))
        except mysql.Error as err:
            print("Failed to create DB: {}".format(err))

        # close cursor and connection
        self.close(cursor, conn)

    #-----------------------------------------------------
    def dropGuiDB(self):
        # connect to MySQL
        conn, cursor = self.connect()
        try:
            cursor.execute(
                "DROP DATABASE {}".format(MySQL.GUIDB))
        except mysql.Error as err:
            print("Failed to drop DB: {}".format(err))

        # close cursor and connection
```

```
        self.close(cursor, conn)

    #-----------------------------------------------------
    def useGuiDB(self, cursor):
        '''Expects open connection.'''
        # select DB
        cursor.execute("USE guidb")

    #-----------------------------------------------------
    def createTables(self):
        # connect to MySQL
        conn, cursor = self.connect()

        self.useGuiDB(cursor)

        # create Individual Table inside DB
        cursor.execute("CREATE TABLE Individual_Learning_Statements (      \
               ID INT NOT NULL AUTO_INCREMENT, \
               Student_Name VARCHAR(108) NOT NULL,    \
               Student_ID VARCHAR(25) NOT NULL DEFAULT 0,        \
               Poed VARCHAR(25) NOT NULL,    \
               Rating VARCHAR(5) NOT NULL,    \
               Assignment VARCHAR(25) NOT NULL,    \
               Date_time VARCHAR(25) NOT NULL,    \
               Team_Number VARCHAR(16) NOT NULL,    \
               Learning_Statements VARCHAR(2500) NOT NULL,    \
               PRIMARY KEY (ID)             \
            ) ENGINE=InnoDB")

        # create Team Table inside DB
        cursor.execute("CREATE TABLE Team_Learning_Statements ( \
               ID INT AUTO_INCREMENT,     \
               Team_Number VARCHAR(16) NOT NULL,    \
               Poed VARCHAR(25) NOT NULL,    \
               Rating VARCHAR(5) NOT NULL,    \
               Assignment VARCHAR(25) NOT NULL,    \
               Date_time VARCHAR(25) NOT NULL,    \
               Learning_Statements VARCHAR(2500) NOT NULL,    \
               PRIMARY KEY (ID)             \
            ) ENGINE=InnoDB")


#       # create second Table inside DB --
#       # No FOREIGN KEY relation to Books Table
#       cursor.execute("CREATE TABLE Quotations ( \
#              Quote_ID INT AUTO_INCREMENT,     \
#              Quotation VARCHAR(250),         \
```

```
#               Books_Book_ID INT,              \
#               PRIMARY KEY (Quote_ID)          \
#           ) ENGINE=InnoDB")

        # close cursor and connection
        self.close(cursor, conn)

    #-----------------------------------------------------
    def dropTables(self):
        # connect to MySQL
        conn, cursor = self.connect()

        self.useGuiDB(cursor)

        cursor.execute("DROP TABLE Individual_Learning_Statements")
        cursor.execute("DROP TABLE Team_Learning_Statements")

        # close cursor and connection
        self.close(cursor, conn)

    #-----------------------------------------------------
    def showTables(self):
        # connect to MySQL
        conn, cursor = self.connect()

        # show Tables from guidb DB
        cursor.execute("SHOW TABLES FROM guidb")
        print(cursor.fetchall())

        # close cursor and connection
        self.close(cursor, conn)

    #-----------------------------------------------------
    def insertIndividualLSs(self, learning_info_str):
        # connect to MySQL
        conn, cursor = self.connect()

        self.useGuiDB(cursor)

        # insert data
        # data format: Student_Name, Student_ID, Poed, Rating, Assignment,
        #            Date_time, Team_Number, Learning_Statements
        cursor.execute("INSERT INTO Individual_Learning_Statements \
            (Student_Name, Student_ID, Poed, Rating, Assignment, \
            Date_time, Team_Number, Learning_Statements) VALUES " + learning_info_str)

        # commit transaction
```

```
        conn.commit ()

        # close cursor and connection
        self.close(cursor, conn)

    #-----------------------------------------------------
    def insertTeamLSs(self, learning_info_str):
        # connect to MySQL
        conn, cursor = self.connect()

        self.useGuiDB(cursor)

        # insert data
        # data format: Team_Number, Poed, Rating, Assignment,
        #            Date_time, Learning_Statements
        cursor.execute("INSERT INTO Team_Learning_Statements \
            (Team_Number, Poed, Rating, Assignment, \
            Date_time, Learning_Statements) VALUES " + learning_info_str)

        # commit transaction
        conn.commit ()

        # close cursor and connection
        self.close(cursor, conn)

    #-----------------------------------------------------
    def selectIndivudualLSs(self, select_infos):
        #change select_infos to string
        select_info_str = ""
        if select_infos:
            select_info_str = " where 1"
            for select_key in select_infos:
                select_info = select_infos[select_key]
                select_values = select_info.split(",")
                new_select_info = ("','").join(select_values)
                where_sql = " and " + select_key + " in ('" + new_select_info + "')"
                select_info_str = select_info_str + where_sql
        # connect to MySQL
        conn, cursor = self.connect()

        self.useGuiDB(cursor)

        # print results
        cursor.execute("SELECT Learning_Statements FROM
Individual_Learning_Statements " + select_info_str + " group by ID")
        selectLss = cursor.fetchall()
```

```
        # close cursor and connection
        self.close(cursor, conn)

        return selectLss

    #-------------------------------------------------------
    def selectTeamLSs(self, select_infos):
        #change select_infos to string
        select_info_str = ""
        if select_infos:
            select_info_str = " where 1"
            for select_key,select_info in select_infos:
                select_values = select_info.split(",")
                new_select_info = ("','").join(select_values)
                where_sql = " and " + select_key + " in ('" + new_select_info + "')"
                select_info_str = select_info_str + where_sql
        # connect to MySQL
        conn, cursor = self.connect()

        self.useGuiDB(cursor)

        # print results
        cursor.execute("SELECT Learning_Statements FROM Team_Learning_Statements " +
select_info_str)
        selectLss = cursor.fetchall()


        # close cursor and connection
        self.close(cursor, conn)

        return selectLss

#-------------------------------------------------------
    def deleteIndividualLSs(self):
        # connect to MySQL
        conn, cursor = self.connect()

        self.useGuiDB(cursor)

        # insert data
        # data format: Student_Name, Student_ID, Poed, Rating, Assignment,
        #            Date_time, Team_Number, Learning_Statements
        cursor.execute("DELETE FROM Individual_Learning_Statements")

        # commit transaction
        conn.commit ()
```

```
        # close cursor and connection
        self.close(cursor, conn)

    #-----------------------------------------------------
    def deleteTeamLSs(self):
        # connect to MySQL
        conn, cursor = self.connect()

        self.useGuiDB(cursor)

        # insert data
        # data format: Team_Number, Poed, Rating, Assignment,
        #            Date_time, Learning_Statements
        cursor.execute("DELETE FROM Team_Learning_Statements")

        # commit transaction
        conn.commit ()

        # close cursor and connection
        self.close(cursor, conn)


#============================================================
if __name__ == '__main__':
    # Create class instance
    mySQL = MySQL()

    #------------------------
    # mySQL.showDBs()
#     mySQL.createGuiDB()
#     mySQL.showDBs()

    #------------------------
#     mySQL.dropGuiDB()
#     mySQL.showDBs()

    #------------------------
#     mySQL.createGuiDB()
#     mySQL.dropTables()
#     mySQL.createTables()
#     mySQL.showTables()

    #------------------------
#     mySQL.showBooks()

    #------------------------
```

```
#    mySQL.showColumns()

    #------------------------
#    mySQL.insertBooksExample()

    #------------------------
#    mySQL.insertBooks('Design Patterns', 7, 'Programming to an Interface, not an
Implementation')
#    mySQL.insertBooks('xUnit Test Patterns', 31, 'Philosophy of Test Automation')
#    mySQL.showData()

    #------------------------
#    mySQL.showData()

    #------------------------
#    mySQL.updateGOF()

    #------------------------
#    mySQL.deleteRecord()
#    book, quote = mySQL.showData()
#    print(book, quote)
```

Text extractor

```
import sys
from datetime import date
from nltk import word_tokenize
from nltk.corpus import stopwords
from nltk.stem import WordNetLemmatizer
import glob

def main():
    dir_name = sys.argv[1]
    today = str(date.today())
    print(today)
    # from the command line to get the files from the 'dir_name' folder
    filenames = glob.glob(dir_name + "/*.txt")
    # get the stop words corpus
    stop_words = set(stopwords.words('english'))
    # add some unique stop words into the corpus
    unique_words = ['takeaways','takeaway','ta',' ','ed','ing']
    stop_words.update(unique_words)
    # get the stemming function to get the stemmer word
```

```
    lemmatizer = WordNetLemmatizer()

    for file_name in filenames:
        # open files to read each line's sentence
        oriFile = open(file_name,'r')
        orilines = oriFile.readlines()
        new_file = ''
        for oriline in orilines:
            new_word_arr = []
            new_oriline = oriline.replace('\n','')
            if(new_oriline == ''):
                continue
            # replace the sepcial characters in the sentence
            new_oriline2 = new_oriline.replace("â€™",' ')
            new_oriline3 = new_oriline2.replace("â€œ",' ')
            new_oriline4 = new_oriline3.replace(',','')
            new_oriline5 = new_oriline4.replace('.','')
            new_oriline6 = new_oriline5.replace('/','')
            new_oriline7 = new_oriline6.replace(':','')
            new_oriline8 = new_oriline7.replace(')','')
            new_oriline9 = new_oriline8.replace("’",'')
            new_oriline10 = new_oriline9.replace("–",' ')
            new_oriline11 = new_oriline10.replace("•",'')
            new_oriline12 = new_oriline11.replace("[",'')
            new_oriline13 = new_oriline12.replace("]",'')
            new_oriline14 = new_oriline13.replace('"','')
            new_oriline15 = new_oriline14.replace('(','')
            new_oriline16 = new_oriline15.replace('—',' ')
            new_oriline17 = new_oriline16.replace('#',' ')
            # change the word to lowercase
            new_oriline_words = new_oriline17.lower()
            ori_word_arr = new_oriline_words.split(" ")
            # filter the stop words and change the word to stemmer
            for ori_word in ori_word_arr:
                if ori_word not in stop_words:
                    new_word = ori_word
                    stemming_word = lemmatizer.lemmatize(new_word)
                    new_word_arr.append(stemming_word)
            # combine the words into a sentence again
            # add into the new file and save into the new folder
            # the new folder name is filter-'old folder name'
            if new_word_arr:
                new_line_str = " ".join(new_word_arr)
                new_file = new_file + "\n" + new_line_str

        new_file_name = 'filter-' + file_name
        fh = open(new_file_name,'w',encoding='utf-8')
```

```
        fh.write(new_file)
        fh.close



if __name__ == "__main__":
    main()
```

Text mining

```
import sys
import numpy as np
from os import path
from datetime import date
import nltk
from nltk import word_tokenize
from nltk.corpus import stopwords
import glob
from pylab import *
import matplotlib.pyplot as plt
from wordcloud import WordCloud
from wordcloud import ImageColorGenerator


def main():
    dir_name = sys.argv[1]
    today = str(date.today())
    print(today)
    filenames = glob.glob(dir_name + "/*.txt")
    d = path.dirname(path.realpath(__file__))
    back_coloring = imread(path.join(d,"oblong.jpeg"))
    #filter_words =
['learn','statement','assignment','ing','help','value','|',"}}<ref>",'*','=']
    filter_words = ['|',"}}<ref>",'*','=']
    for file_name in filenames:
        oriFile = open(file_name,'r')
        oritexts = oriFile.read()
        oriwords = oritexts.replace('\n',' ')
        for filter_word in filter_words:
            oriwords = oriwords.replace(filter_word,'')
        oriwords = oriwords.replace("'","")
        oriwords = oriwords.replace(',','')
        oriwords = oriwords.replace('  ',' ')
```

```
        ori_word_arr = oriwords.split(" ")
        fdist = nltk.FreqDist(ori_word_arr)
        frenquency_words = dict(fdist.most_common(8))
        sorted(frenquency_words)
        print(frenquency_words)
        sum_num = 0
        for key in frenquency_words:
            fValue = frenquency_words[key]
            sum_num = sum_num + int(fValue)
        print(sum_num)
        plt.figure(figsize=(10,3))
        plt.title(file_name)
        ax1 = plt.subplot(1,2,1)
        ax2 = plt.subplot(1,2,2)
        x_arr = []
        y_arr = []
        for fren_key in frenquency_words.keys():
            x_arr.append(fren_key)
            y_arr.append(frenquency_words[fren_key])
        plt.sca(ax1)
        plt.title(file_name)
        plt.grid(axis="y")
        plt.bar(x_arr,y_arr)
        plt.xticks(rotation=10,fontsize=8)

        wc = WordCloud(
            mode='RGBA',
            colormap='Dark2_r',
            background_color="white",
            mask=back_coloring,
            max_font_size=150,
            random_state=42,
            prefer_horizontal=0.8
            )
        wc.generate_from_frequencies(frequencies=frenquency_words)

        image_colors = ImageColorGenerator(back_coloring)
        plt.sca(ax2)
        # show word cloud
        plt.imshow(wc)
        plt.axis("off")
        plt.show()

if __name__ == "__main__":
    main()
```

Text similarity

```
import gensim
import nltk
import glob
import re
import codecs
import math
import scipy
import numpy


def createModels(filenames):
   #filenames = ['books/sherlock_adventures.txt',
'books/sherlock_baskervilles.txt']
   #filenames = ['books/sherlock_adventures.txt', 'books/plato_republic.txt']
   #filenames = ['books/sherlock_adventures.txt', 'books/sherlock_adventures.txt']
   tokenizer = nltk.data.load('nltk:tokenizers/punkt/english.pickle')

   models = []


   for fname in filenames:
      print("Current file: '{0}'".format(fname))

      with codecs.open(fname, "r", "utf-8") as fin:
         corpus = fin.read()
      #fin = open(fname, 'r')
      #corpus = fin.read()

      sentences = tokenizer.tokenize(corpus)
      #print("Sentences: '{0}'".format(sentences))

      words = []
      for sentence in sentences:
         cleanSentence = re.sub("[^a-zA-Z]", " ", sentence)
         words.append(cleanSentence.lower().split())

      #print("Words: '{0}'".format(words))
      count = len(words)
      #print("count = '{0}'".format(count))

      model = gensim.models.Word2Vec(sg=1, seed=123, workers=1, size=100,
window=10, min_count=10)
```

```
        model.build_vocab(words)
        model.train(words, total_examples=model.corpus_count, epochs=model.iter)
        models.append(model)

    return models


''' #first candidate for distance
distance = 0
count = 0
for model1 in models:
    for model2 in models:
        for word1 in model1.wv.vocab:
            for word2 in model2.wv.vocab:
                if word1==word2:
                    #print("m1 w1 '{0}'".format(model1.wv[word1]))
                    #print("m2 w2 '{0}'".format(model2.wv[word2]))
                    distance += 1-scipy.spatial.distance.cosine(model1.wv[word1],
model2.wv[word2])
                    count += 1
                    #print("distance '{0}'".format(distance))
distance = distance/count
print("final distance '{0}'".format(distance))
'''

def findDistance(model1, model2):
    distanceMat = []
    count = 0
    distance = 0
    for word1 in model1.wv.vocab:
        for word2 in model2.wv.vocab:
            if word1==word2:
                #print("m1 w1 '{0}'".format(model1.wv[word1]))
                #print("m2 w2 '{0}'".format(model2.wv[word2]))
                w1 = numpy.linalg.norm(model1.wv[word1])
                w2 = numpy.linalg.norm(model2.wv[word2])
                #distance += numpy.power((w1-w2),2)
                distance += abs(w1-w2)
                count += 1
                #print("distance '{0}'".format(distance))
                #distanceMat[models.index(model1)][models.index(model2)] =
math.sqrt(distance)
    if count != 0:
        return 100*distance/count
    else:
        return 1000
```

```
def main():
    distMat = []
    filenames1 = glob.glob("0624text2017/*.txt")
    filenames2 = glob.glob("0624text2018/*.txt")
    models = createModels(filenames1)
    models2 = createModels(filenames2)
    count = 0
    for fname1 in filenames1:
        distRow = []
        for fname2 in filenames2:
            id1 = models[filenames1.index(fname1)]
            id2 = models2[filenames2.index(fname2)]
            #if id2>=id1:
            #   continue
            dist = findDistance(id1, id2)
            distRow.append(dist)
            print("Distance between \"" + fname1 + "\" and \"" + fname2 +"\" : "+
str(dist))
        distMat.append(distRow)
    print(distMat)

if __name__ == "__main__":
    main()
```

Text network

```
#coding: utf-8
import sys
import numpy as np
from os import path
from datetime import date
import nltk
from nltk import word_tokenize
from nltk.corpus import stopwords
import glob
from pylab import *
import csv


def main():
    dir_name = sys.argv[1]
    today = str(date.today())
```

```
    print(today)
    filenames = glob.glob(dir_name + "/*.txt")
    d = path.dirname(path.realpath(__file__))
    back_coloring = imread(path.join(d,"oblong.jpeg"))
    #filter_words =
['learn','statement','assignment','ing','help','value','|',"}}<ref>",'*','=']
    filter_words =
['learn','statement','assignment','help','value','|',"}}<ref>",'*','=']
    for file_name in filenames:
        node_arr = {}
        edge_arr = {}
        node_key = 0
        oriFile = open(file_name,'r')
        for oritext in oriFile.readlines():
            oriwords = oritext.replace('\n',' ')
            for filter_word in filter_words:
                oriwords = oriwords.replace(filter_word,'')
                oriwords = oriwords.replace('  ',' ')
            ori_word_arr = oriwords.split(" ")
            i = 0
            for sword in ori_word_arr:
                if sword == '' or sword == ' ':
                    continue
                if sword not in node_arr:
                    node_arr[node_key] = sword
                    node_key = node_key + 1
                if i != 0:
                    j = 0
                    while j < i:
                        distance = i - j
                        edge = round(1/distance, 4)
                        compare_word = ori_word_arr[j]
                        if compare_word != sword:
                            edge_key = compare_word + '_' + sword
                            if edge_key not in edge_arr.keys():
                                edge_arr[edge_key] = edge
                            else:
                                edge_arr[edge_key] = edge_arr[edge_key] + edge
                        j = j + 1
                i = i + 1
        # sort the edge value
        #tempEdges = zip(edge_arr.keys(), edge_arr.values())
        #sorted_edges = sorted(tempEdges, key=lambda tempEdges: tempEdges[1],
reverse=True)
        #sorted_edges_dicts = dict(sorted_edges)
        node_dicts = dict(zip(node_arr.values(),node_arr.keys()))
        # re-construct the data and edges for export the csv file
```

```
        node_csv_arr = {}
        edge_csv_arr = []
        edge_csv_key = 0
        for ekey in edge_arr.keys():
            weight = edge_arr[ekey]
            if weight <= 5:
                continue
            edge_words = ekey.split('_')
            if edge_words[0] == '' or edge_words[1] == '':
                continue
            nodeone_key = node_dicts[edge_words[0]]
            nodetwo_key = node_dicts[edge_words[1]]
            if nodeone_key not in node_csv_arr.keys():
                node_csv_arr[nodeone_key] = edge_words[0]
            if nodetwo_key not in node_csv_arr.keys():
                node_csv_arr[nodetwo_key] = edge_words[1]
            #edge_line =
{'Source':nodeone_key,'Target':nodetwo_key,'Type':'directed','id':edge_csv_key,'Weig
ht':weight}
            edge_line = (nodeone_key,nodetwo_key,'directed',edge_csv_key,weight)
            edge_csv_arr.append(edge_line)
            edge_csv_key = edge_csv_key + 1
        # export two csv files: node and edge
        node_csv_data = zip(node_csv_arr.keys(), node_csv_arr.values())
        nodecsvfile = open(file_name+'-node.csv','w')
        node_writer = csv.writer(nodecsvfile)
        node_writer.writerow(['Id','Label'])
        node_writer.writerows(node_csv_data)
        nodecsvfile.close()
        # export two csv files: node and edge
        edgecsvfile = open(file_name+'-edge.csv','w')
        edge_writer = csv.writer(edgecsvfile)
        edge_writer.writerow(['Source','Target','Type','Id','Weight'])
        edge_writer.writerows(edge_csv_arr)
        edgecsvfile.close()




if __name__ == "__main__":
    main()
```