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Applications of narrative to the engineering decision making process and the pedagogy of engineering education

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by

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TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

Narrative is defined as a basic form of human communication. It is through narrative that humans experience and comprehend life. Using narrative as a tool to improve communication and comprehension requires incorporating several components into a complete narrative structure. The components of a narrative consist of a story; that is, a sequence of events providing chronological order and context to a subject, and a method of discourse; that is, the means in which the story is told. Creating narrative allows for increased cognitive understanding of a subject because it is the way in which we as humans naturally communicate. This paper examines how narrative may be used in engineering decision making. Engineering is a field where data is often presented with little context. This data is difficult to understand at first glance and occasionally requires explanation from experts closest to the data set. Engineering courses are not much different in that students are often faced with computational problems that are taken out of context. Practice in solving problems is necessary; however, these problems are often out of context and use idealized situations, thus hindering students' ability to transfer knowledge to new situations. Using narrative to place problems in a real world context allows the students to experience situations closer to real world working environments. Outside of the engineering classroom, engineers face large amounts of data generated from projects with large design teams. Arranging the data into a narrative by adding layers of context can aid in comprehension of project data and also help bridge communication gaps between multiple engineering disciplines. Engineering groups tend to do this today, and indeed many companies have formalized engineering processes that unknowingly create a narrative. Understanding the nature of narrative can improve these

processes. In addition, engineering software today is like a shattered mosaic of brilliant colors, and building software that brings these pieces of the mosaic into a coherent, integrated picture would significantly benefit the engineering decision making process.

CHAPTER 1. OVERVIEW

"Narrative is not just a matter of paying attention to individual incidents on the time-line; it is most importantly about 'expectation' and 'memory': reading the end in the beginning and reading the beginning in the end."

Paul Cobley (Cobley 2001, 19)

Narratives, more commonly referred to as stories, tell of origins, explain causes, construct boundaries of what is knowable and explore the territories beyond. As we remember, interpret, plan and dream through stories, they give form to the fleeting nature of experience (Potteiger & Purinton 1998). Though narrative can be synonymous with story, narrative is a more comprehensive and inclusive term referring to both the story; that is, what is told, and the means of telling. These attributes imply both product and process, form and formation, structure and structuration (Potteiger & Purinton 1998). The story component contains the content of what is being told such as characters, events, and settings. The discourse; that is, the method of expression can be manifest in verbal or written form or as film, dance, or areas of design such as landscape and architecture. Regardless of the chosen discourse, the motive for narrative remains the same, the need for human communication.

Using narrative as a tool to improve communication and comprehension requires incorporating pieces that build a complete narrative structure. Narrative is defined by Prince as the representation of at least two real or fictive events (Prince 2003), implying that narrative is sensitive to chronological order. An event's place in time is part of providing context to the event, which is also a requirement for a complete narrative. Creating narrative allows for increased cognitive understanding of a subject because it is the way in which we as humans naturally communicate. An example may be a description of a trip to the grocery store. Only stating the nouns, “grocery store, milk, eggs”, would not mean much to a naratee even though all the factual data had been covered. However adding context with the statement, “I will go to the grocery store for milk and eggs” gives the naratee an indication of time, motive, and who was involved, a much more comprehensive story. By applying narrative to otherwise out-of-context data, receivers of the information would be able to reach an understanding quickly and effortlessly. Narrative also conveys a sense of rising and falling intensity. To help illustrate the rise in tension, the following questions can be asked about the trip to the grocery store. Will I be able to find the store? Does the grocery store have milk or eggs available? There is a rising sense of intensity while a problem is explored and the outcome is uncertain. When a solution begins to take shape, this sense of intensity begins to decrease. Another way one experiences this sense is while listening to music. Phrases within a piece of music convey a narrative sense of rising and falling intensity, thus providing a way to experience narrative in an intuitive way.

Engineering is a field where data is often presented with little context. This data is difficult to understand at first glance and occasionally requires explanation from the experts closest to the data set. The engineering classroom is not much different in that students are faced with computational problems that are taken out of context. Practice in solving problems is necessary; however, these problems are often out of context and use idealized situations, thus hindering students’ ability to transfer knowledge to new situations. Placing problems in a real world context allows the students to experience situations closer to real world working environments. Outside of academia, engineers face large amounts of data generated from projects with large design teams. Arranging the data into a narrative by adding layers of context would aid in comprehension of project data and also help bridge communication gaps between multiple engineering disciplines.

Furthering the description of narrative is the Narrative Paradigm developed by narrative theorist Walter Fisher. He suggests that humans communicate through narrative and experience and comprehend life through a series of ongoing narratives (Fisher 1987). It is through the recounting of events that we are able to share knowledge, entertain, and collaborate. Fisher's Narrative Paradigm sees people as storytellers; that is, as authors and co-authors who creatively read and evaluate the texts of life and stories they have heard or read. A narrative perspective focuses on the idea that existing institutions provide "plots" that are always in the process of re-creation rather than existing as settled scripts. Viewing human communication narratively stresses that people are full participants in the making of messages, whether they are agents (authors) or audience members (co-authors)(Fisher 1987).

A popular tool in describing a story structure is Freytag's Pyramid [Figure 1.1]. This serves as a visual representation of the plot development of a tragedy and the description of the five main components of the plot: (*a*) introduction, (*b*) rise, (*c*) climax, (*d*) return or fall, (*e*) catastrophe (Freytag, 1900). Freytag's Pyramid is a visual example of the rise in tension to the climax and then the release, much like what one experiences while listening to a phrase in a piece of music. Freytag's Pyramid is the key to relating engineering design with narrative. The engineering design process can be described using the pyramid's five components: (*a*)

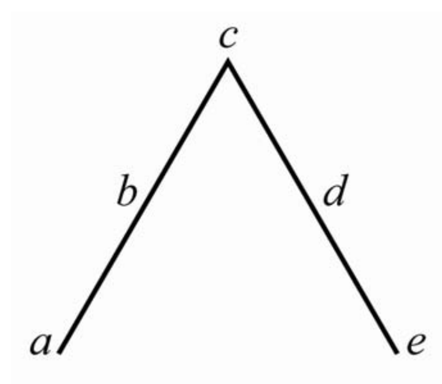

Figure 1.1 Freytag's Pyramid

problem, (*b*) defining the solution, (*c*) solution, (*d*) product realization, and (*e*) final product. Using this structure as a basic form, a more complex narrative can be built on top of it. Much like music composition, a story structure is rarely one smooth ascent to the climax; rather, it is a series of tension builds and releases that move in the direction of the main climax. Freytag's Pyramid is useful in illustrating how narrative moves forward through time. It also enables application of narrative to data that would otherwise be without context.

Chapter 2 discusses the application of narrative to engineering design. Specifically, how narrative and Freytag's Pyramid are used in the engineering design process and why this is necessary is discussed. The following is a brief introduction to this discussion.

Engineers of the present and future face more difficult and complex problems than any other time in history. In the past a single engineer would control the entire narrative of a project. He would make all the final decisions regarding a project without keeping a comprehensive record of the context in which a decision was made. Projects of today are far too complex for a single engineer; they require teams of engineers, each specializing in a portion of the project. Communication can be difficult, and project decisions must be made that will affect other collaborators. Because of this, there is a need for engineering design software to incorporate a decision making environment. This environment should provide a big picture view of a project and provide the ability to view contextual information and relationships at each decision point. Developing software to generate a narrative would begin to construct a framework for a decision-making environment.

If narrative can be defined as the way in which humans communicate (Fisher 1987), then developing a narrative to describe complex problems should help bring clarity and understanding. Engineering design is similar to the structure of literary narrative in that it is defining a solution that moves forward to the climax, or a viable solution. Product realization is a release in the overall project tension as it moves toward a developed product, or conclusion. This process is demonstrated in Figure 1.2 where aspects of engineering design are overlaid on the narrative tool, Freytag's Pyramid.

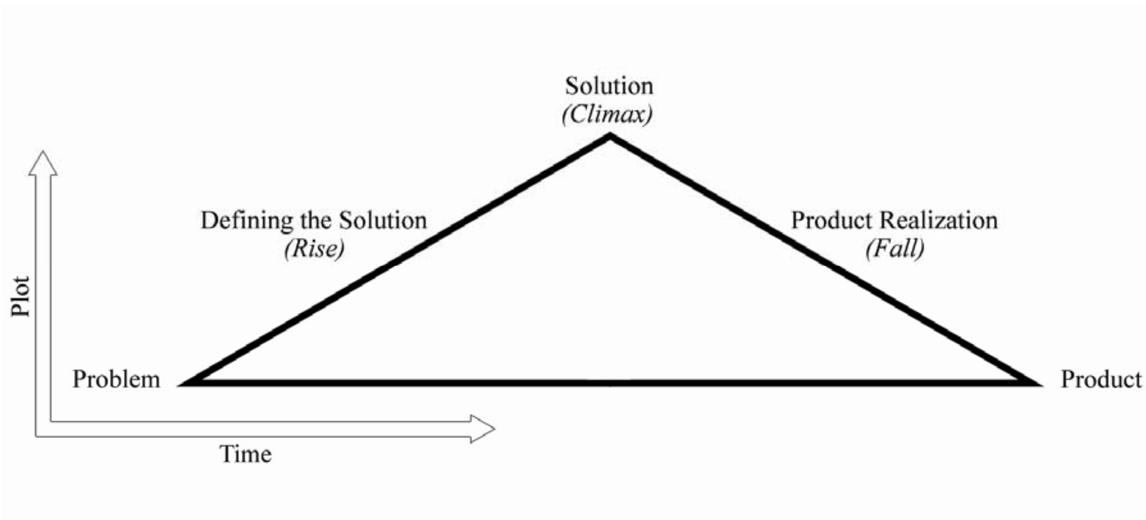

Figure 1.2 Engineering design over Freytag's Pyramid

To enable a complete narrative structure, context including setting and time are required elements. These are achieved in engineering design by keeping a record of changes in design made at points in time along with linking any relevant information to create a decision point. A set of decision points will create a historical timeline of the project's life span. This timeline will illustrate the direction of the project and show possible alternate routes that were not taken or abandoned, giving the user the knowledge to move forward in designing a better solution. The complete narrative of the project is created by linking the decision points and following their path from problem to climax to conclusion.

A complete narrative of a project would allow for quick decision making in regards to project decisions. Having a project description in a form that all users can quickly comprehend would be a valuable tool for any engineer regardless of specialization. Making decisions quickly and efficiently in a large engineering project can be a daunting task. However, software tools designed to work in the same way humans think should improve communication and comprehension to levels yet to be experienced in engineering design.

Further expanding on narrative and how it can be applied, chapter 3 discusses the application of narrative to engineering education. The following offers an introduction to the material.

In the spring of 2008 at Iowa State University, 81 students enrolled in the sophomore engineering course "Introduction to Thermodynamics". This course had been designed to move away from the traditional homework/lecture structure to incorporate narrative based tools and encourage student-generated content for the course material. These tools included adding real world context, video based instruction, and web forum tools to encourage student discussion of thermodynamics related topics. The goal was to place the thermodynamics topics within context, thus enabling students to create a personal narrative of the information. Collaboration and exposure to real world problems would better prepare students for future job environments, an experience often missing in academia.

Incorporating narrative into this course required several approaches. The biggest change from the homework/lecture paradigm (Foertsch, Moses, Strikwerda, & Litzkow 2002) was the addition of lecture videos. The course instructor pre-recorded video discussing course content which were converted to a web format and distributed through the course website. The initial plan for the videos was to incorporate video footage of real world locations paired with applicable course topics. Video also would enable the use of animation and other dynamic visualization to better create a narrative of the concepts in thermodynamics. However, the initial version of the videos did not include this dynamic content. Instead the videos became a technical proof of concept. Issues in new distribution techniques, through Apple’s iTunesU music store, and audio/video equipment troubles reduced the time available to create comprehensive dynamic content. To prevent the students from being at a disadvantage, efforts focused on creating simplistic videos which all students could access to ensure all required course content was covered.

Another approach to creating a narrative was the discussion forums embedded in the course web page. This space provided students with added means of communication with their peers. Also, these forums provided space to share external content relevant to thermodynamics. Initially the course instructor posted a link to an external article and briefly described its relevancy to thermodynamics. The students followed in turn by finding and sharing articles as well as posting discussion comments on their colleague’s choices. It is of note that posting articles and commenting was not a requirement for the course and students were not awarded credit; however, towards the end of the course over 80 articles had been posted with added discussion. The intent of this exercise was to encourage students to add context to the course in a way that was meaningful to them. The articles, usually with topics discussing future power sources, added real world application of the course topics. In addition, the following discussions enabled students to begin creating an understanding of the topics using their own words.

To further increase the students’ exposure to creating their own narrative for the course, a final project was introduced which required applying the learned thermodynamics topics to real world situations. Students were encouraged to choose topics from the available articles posted in the forums but it was not a requirement. They were asked to provide some background of the topic, and to provide an analysis based on conservation of mass and energy, as well as the entropy equation. In general, students were able to write these equations quite easily but found the process of finding real numbers extremely challenging. Nonetheless, most were successful.

The tools and teaching strategies developed in this course provide a starting place to bring narrative into an otherwise computational based course. To help improve these techniques for future use, students were encouraged to comment through surveys, the web forum, and the course evaluation form. Their comments helped highlight aspects that the students found valuable or required changes. The largest number of negative comments focused on the quality and distribution methods for the video content. Some of the positive comments described the students' perceived usefulness of the article activities. Other comments described the usefulness of the video lectures, because their use allowed class time to be reserved for problem solving and interaction with the course instructor. Although the techniques used to apply narrative to an engineering course will evolve, the feedback pointed to an overall success.

CHAPTER 2. APPLICATION OF NARRATIVE TO ENGINEERING DESIGN SOFTWARE

In the past the narrative for an engineering project has been controlled by a single person such as a chief engineer. This engineer would know every detail about a project and the sequence of events that were needed to complete the project. As complexity grows in projects in our current age, it is no longer possible for a single engineer to maintain the narrative for the project. This requires the creation of new methods and processes to maintain and encourage narrative in engineering design. This document describes how to apply narrative to engineering design software through the use of established literary tools. Using engineering design software to construct a narrative from the data already contained within a project can create a framework for a decision-making environment. Narrative within this environment can improve communication and comprehension among people with diverse skill sets in an engineering design project.

2.1 Introduction

The earliest cave paintings, dated at 40,000 years old, depict herds of animals and warriors on a hunt. These early images are narratives describing the artist's experience during the hunt. These early cave paintings are some of the oldest existing records of human narrative. Narratives, more commonly referred to as stories, tell of origins, explain causes, construct the boundaries of what is knowable and explore the territories beyond. As we remember, interpret, plan and dream through stories, they give form to the fleeting nature of experience (Potteiger & Purinton 1998). The chosen discourse of the prehistoric narrative was etching and painting on a cave wall. Today there are a wide variety of methods for the discourse. People are mesmerized by stories about digitally created dinosaurs displayed on screens at their local movie theater. One can become lost in the almost endless amount of fiction and non-fiction text published on the Internet. In high-tech labs scientists and engineers can immerse themselves in visually realistic virtual worlds to study the latest in human innovation. The narratives presented in each of these examples, regardless of the chosen discourse, share the same motive as the early cave paintings, the need for human communication.

In the past the narrative for an engineering project has traditionally been managed by a single person such as a chief engineer. This engineer would know every detail about a project and the sequence of events that were needed to complete the project. In addition, this engineer would be making the majority of decisions for completing the project. This process of completing projects was possible because the complexity of the project was manageable for this time period. As complexity grows in projects in our current age, it is no longer possible for a single engineer to maintain the narrative for the project. The design studies undertaken to date have shown that designers have problems with cognitive overload (Miles, Hall, Noyes, Parmee, & Simons 2006). This requires the creation of new methods and processes to maintain and encourage narrative in engineering design.

2.2 Narrative

Walter Fisher, a narrative theorist, developed the Narrative Paradigm, which states that humans communicate through narrative and therefore experience and comprehend life through a series of ongoing narratives (Fisher 1987). The narrative paradigm sees people as storytellers; that is, as authors and co-authors who creatively read and evaluate the texts of life and literature. A narrative perspective focuses on the idea that existing institutions provide "plots" that are always in the process of re-creation rather than existing as settled scripts. Viewing human communication narratively stresses that people are full participants in the making of messages, whether they are agents (authors) or audience members (co-authors) (Fisher 1987).

If narrative is viewed as a basic structure for human communication and the way in which humans perceive the world, then narrative is a comprehensive means of delivering information. Arranging information as a narrative means building a chronological structure of information, thus giving the narratee a sequence of events to follow. The sequence of related events creates context, which allows the narratee to have a better conceptual understanding of the topic as a whole. When context is added, the narrative will begin to acquire aspects of a traditional story, which according to Fisher, is a natural way for humans to comprehend information.

The term narrative is defined as the representation of one or more real or fictive events communicated by one or more narrators to one or more narratees (Prince 2003). Narrative can be described as the way in which we as humans communicate; through the recounting of events we are able to share knowledge, entertain, and collaborate. A narrative is often referred to as a story; although narrative can be synonymous with story, narrative is a more comprehensive and inclusive term than story (Prince 2003). Narrative refers to both the story; i.e. what is told, and the means of telling, thus implying both product and process, form and formation, structure and structuration (Potteiger & Purinton 1998). The story will contain the content of what is being told such as characters, events, and settings. The discourse or, method of expression, is manifest as verbal or written communication, film, dance, or areas of design such as landscape and architecture. The story combined with the discourse creates a complete narrative structure.

2.3 Engineering Design

Today many design problems are multi-disciplinary and involve large design teams. (Miles, Hall, Noyes, Parmee, & Simons 2006). Design teams use computers and a variety of software to develop products and solutions, highlighting a need for improving communication between the user and the computer. Specific deficiencies in current technologies are found in the areas of the following (Miles, Hall, Noyes, Parmee, & Simons 2006):

- Understanding Humans
- Representation
- Enabling environment for collaboration and user interaction
- Two way knowledge capture
- Search and exploration

These issues share a common thread of improving communication between the user and computer, and communication between users. Narrative, the means in which humans communicate, is able to address these problems.

Engineers in the design phase of a project currently use computers paired with computer aided design software. An advantage to working with computers is that they are able to output and store data either on command or as a background process. This aspect could potentially be used to store data pertaining to changes in a design or certain data sets used for reference on a design decision. Linking this stored record of project decisions begins to build context for the project. A chronological structure gives the narratee a sequence of events to follow. Other project data that may be stored includes user identification, outside references or data sets, user comments, and screen captures. All of the stored information creates context for a particular point in the chronological history of the project design, which enables the narratee to have a better conceptual understanding of the project.

Once these data records are created, they can be internalized and made into a discourse by various mechanisms (Crawford 2002). The data then can be treated as objects to construct a comprehensive virtual environment. After that narratives can be created from the objects within this environment. Each respective narrative can be constructed from a different perspective (Meadows 2002). Understanding and discussing the differences and similarities in these narratives can aid in the interpretation and understanding of the project as a whole. Object narratives in virtual engineering can help teams of engineers understand and solve problems because virtual objects, unlike physical objects, can store snapshots of information at various points in time (McCorkel & Bryden 2007). These snapshots can then be revisited and discussed to better understand a product's successes and failures. When viewed over time, objects can provide a map for future reference to understand how knowledge was gained and to bring that knowledge forward to the product currently being designed.

A popular approach that has been used to describe the process of writing a novel is Freytag's Pyramid [Figure 2.1], which serves as a visual representation of plot development, in this case a tragedy, and the description of the five main components of the plot: (*a*) introduction, (*b*) rise, (*c*) climax, (*d*) return or fall, (*e*) catastrophe (Freytag 1900). Each of these components represents not only the main plot of the story, but also the story's subplots. In other words, a primary Freytag Pyramid might describe the main plot, but embedded in that pyramid might be several sub-triangles representing the novel's subplots. This same analogy can be applied to the engineering process. The overall task of developing a product includes three stages parallel to those outlined for Freytag's Pyramid. At the beginning of a project, the engineering staff, marketing, and business strategy teams ramp up to begin to understand what really must be done to develop the new product [Figure 2.2].

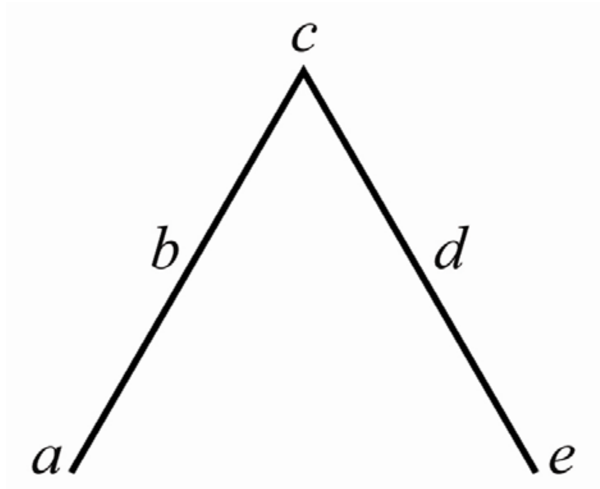

Figure 2.1 Freytag's Pyramid

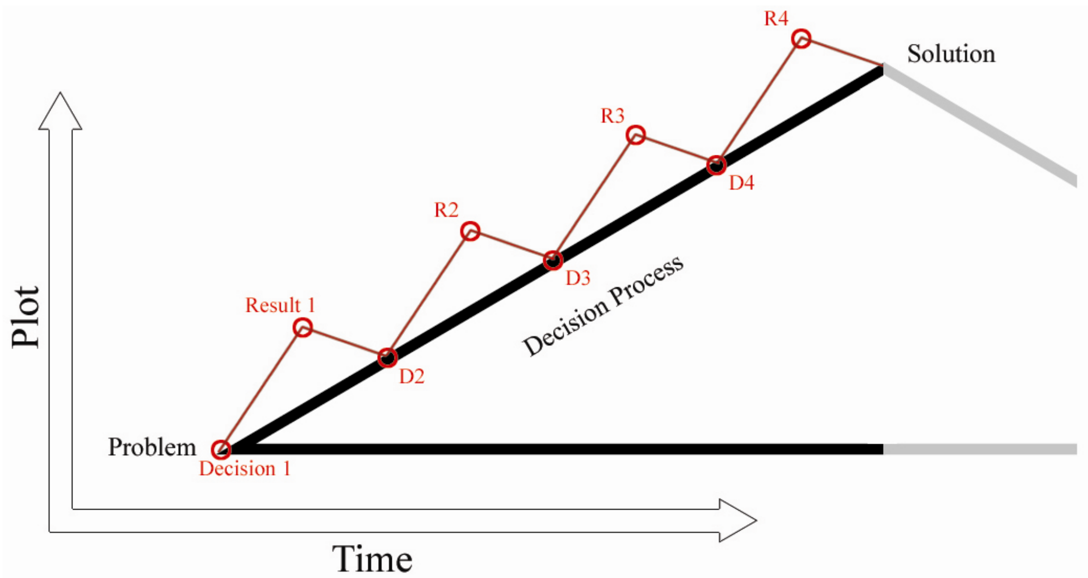

Figure 2.2 Decision point pyramid

The peak of this process is the realization of the product and what must be accomplished to bring the product to market. From this point, the product team knows what must be done and the deadlines that must be met. Freytag's Pyramid can then be overlaid in time with the decision points to show how the product moves forward [Figure 2.3].

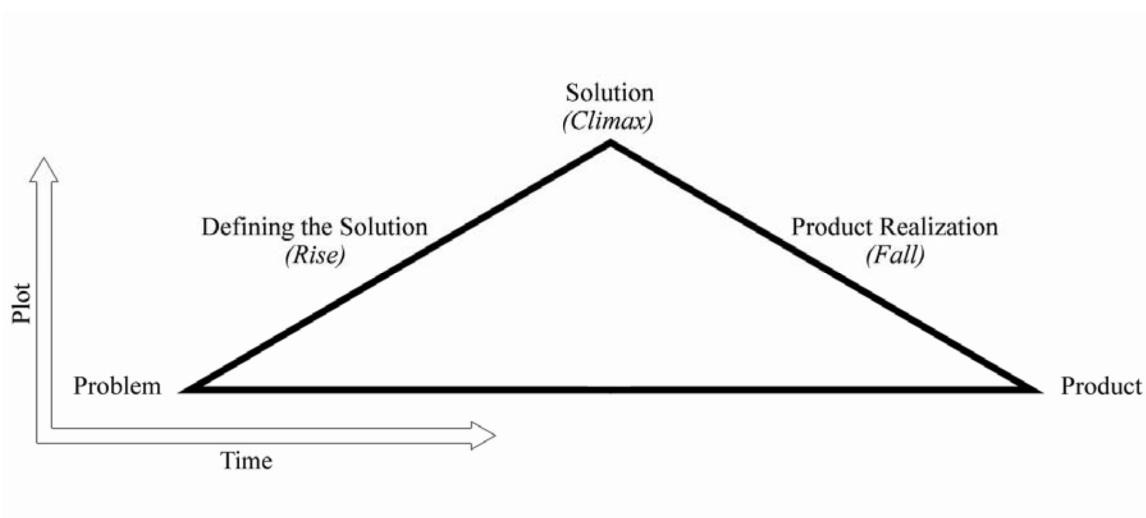

Figure 2.3 Engineering design over Freytag's Pyramid

According to Meadows, running an application is an interactive form of reading (Meadows 2002). Engineering software should follow steps to create knowledge for the engineer in a similar way that reading creates knowledge for the reader. If the reader does not understand a particular text, he or she can move to another outside reference at any point of the reading process to enhance their knowledge acquisition.

Another component is the use case scenario diagram [Figure 2.4].

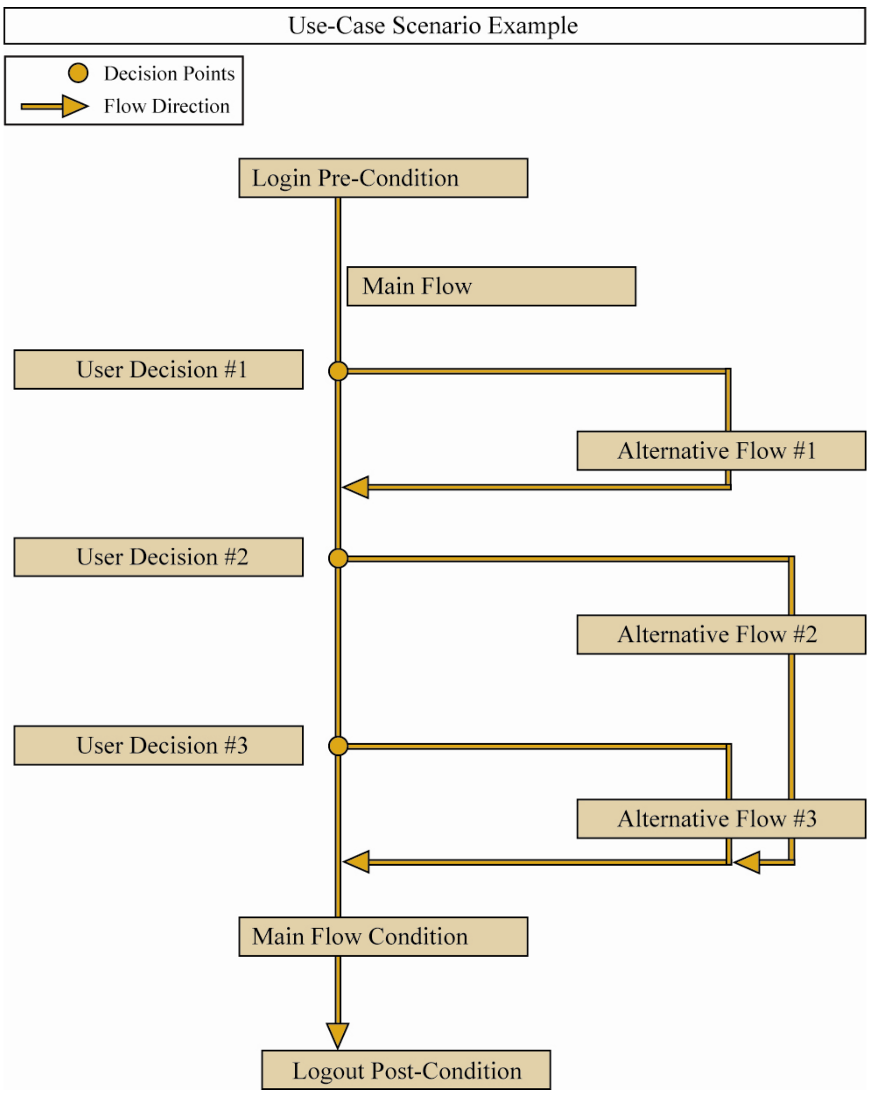

Figure 2.4 Use-Case Scenario Example (Meadows 2002, 27)

This scenario is typical of the current engineering design process. It illustrates an inability to move backwards in the process, resulting in disconnected and inadequate communication processes. Again, the process of reading can provide an analogy to a more natural process for engineering. The engineering process should support a continuous workflow [Figure 2.5]. As

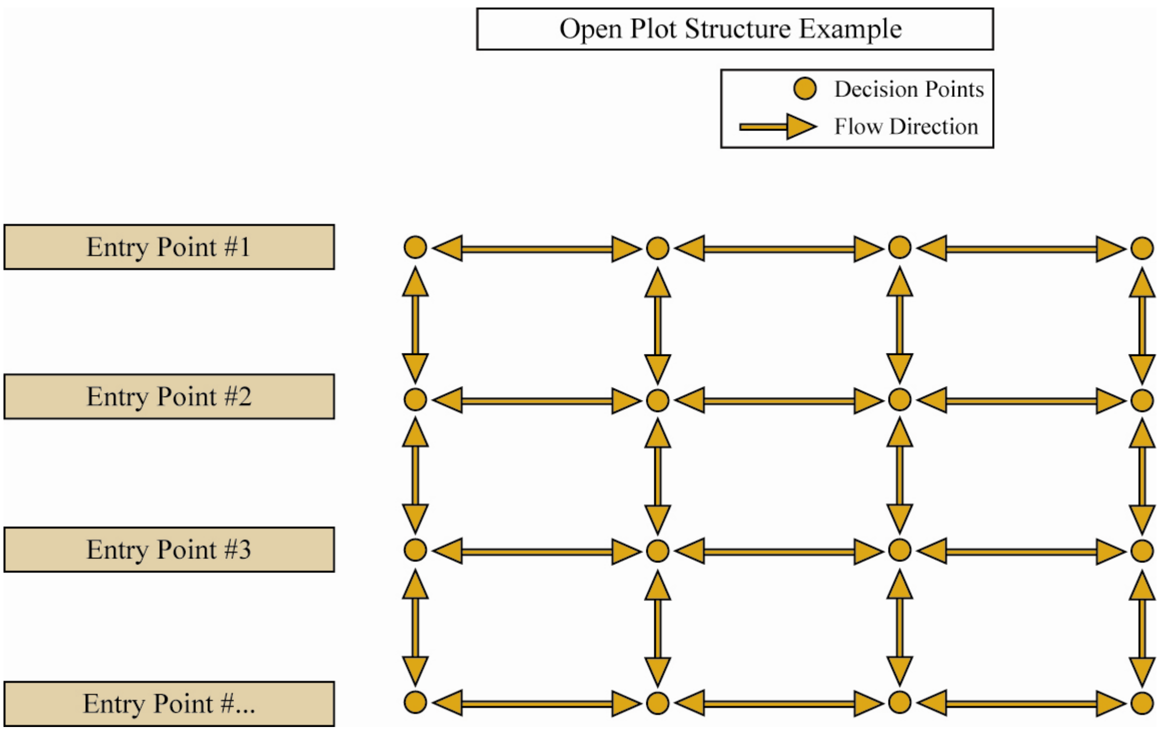

Figure 2.5 Open Plot Structure Example (Meadows 2002, 66)

Meadows demonstrates, the future of interacting with software tools may look like Figure 2.6. This process enables the user to become any number of characters in a process to look at the same environment from different perspectives. This ability in the engineering process is critical to improving the effectiveness of engineering teams. It provides engineers a way to gain experiences that would otherwise be lost or unattainable to those outside the experience.

A truly interactive narrative environment enables engineers to share experiences rather than having to look in from the outside. Enabling this process to take place in software requires

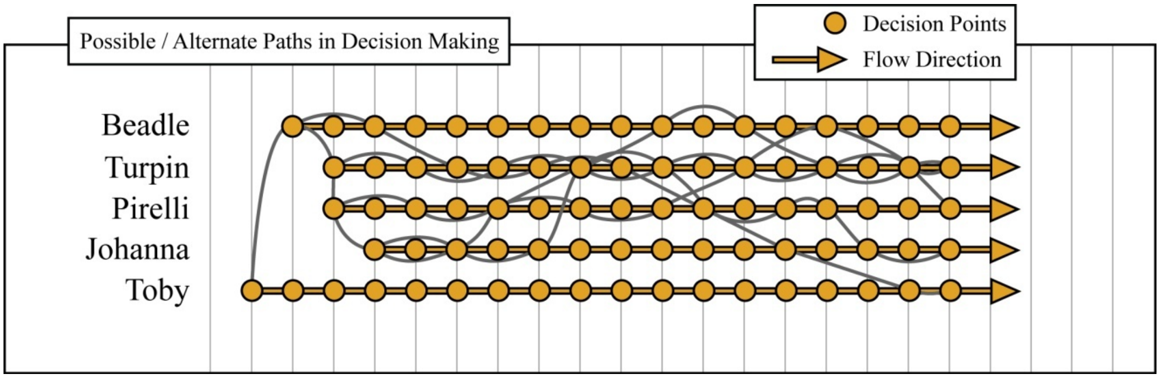

Figure 2.6 Possible / Alternate Paths in Decision Making Diagram (Derived from Meadows 2002)

the use of objects that draw the user through a story. Objects are used in everyday life to remind us of past events and to move us mentally from one thought to another. Architects use objects to move someone through a building or to evoke emotion about the building or what is being displayed in the building (McCorkle, Bryden, & Ashlock 2006). Games use objects to convey information about the environment in which the game is taking place or about items that the user captures in the game.

2.4 Conclusions

Engineering projects have become far too complicated for a single lead engineer to manage the entire narrative. Projects require multiple experts from multiple engineering disciplines, each of whom oversees only a piece of a larger project. Conceptual understanding of the entire project is necessary because each part of the project affects the whole. Narrative is a means in which to tie project data together with a single thread. The thread itself is a representation of time, and each design change and project decision are objects on its path. Layers of context, including time, influences, and users are recorded within these objects. Time and context make the objects part of a comprehensive narrative. When the project reaches the stage of conclusion, based on the structure of Freytag's Pyramid, the narrative becomes complete. A complete narrative allows users to view a historical record that illustrates the direction of a project, showing possible alternate routes and abandoned routes. The user is able to quickly view the contextual information at each decision point. Because it is based on understanding of narrative regarding how humans communicate, this human and computer interaction model would be a design improvement of existing engineering design packages.

We live within worlds of stories, and we use stories to shape those worlds (Potteiger & Purinton 1998). Stories are able to carry much more information, such as context and chronological order to events, than numerical data output alone. Using stories in engineering design will enable engineers to quickly comprehend data and make decisions, shaping our world faster and more efficiently.

CHAPTER 3. APPLICATION OF NARRATIVE: ALTERNATIVE PEDAGOGY OF ENGINEERING EDUCATION

In an effort to design new tools and strategies for future distance courses, a sophomore engineering course was designed to incorporate narrative based concepts. The goal of developing new methods of sharing information in an academic environment is to contribute to the improvement of student collaboration, communication, and conceptual understanding of course concepts. Students enrolled in this course were given access to a website that provided a space for a class schedule, homework postings, supplemental material, and discussion boards. Students were encouraged to use the discussion boards to communicate with their colleagues as well as post outside content relevant to the course subject, thermodynamics. In addition to the website, traditional classroom lectures were replaced with ten to twenty minute web videos with each covering a specific topic. This allowed students to view lectures on their own. Class time was then used for hands-on problem solving and questions.

Two surveys administered over the length of the course were designed to evaluate the students' perceived effectiveness of the course tools and format. The findings show that the students found both the website and the videos useful to their understanding of the material. The website forum was particularly useful in encouraging student interaction. All of the questions regarding the material along with solution suggestions were student generated with little interaction needed from the course instructor. Other narrative aspects introduced to the course also were successful; however, the most valuable aspects of this study were the videos and the success of the class web forum.

3.1 Introduction

Pedagogy of engineering education in the United States has been slow to incorporate new theories and information on how people learn. Currently the typical engineering course involves study from textbook chapters that have limited continuity between topics. In many cases the book chapters are paired with traditional lectures as the underlying structure for information delivery. This method allows only for a one-way flow of information from the professor to the student, which assumes that students are passive receivers of information (Foertsch, Moses, Strikwerda, & Litzkow 2002) (Berryman 1991). This flow of information does not allow students a chance to actively participate in learning the material. Furthermore, class time used for lecture forces students to attempt problem-solving exercises outside of class without direct interaction with the professor. These problem-solving exercises, which are assigned as homework, are problems taken out of context and that use idealized situations, thus hindering the students' ability to transfer knowledge to new situations. These methods do not encourage students to develop the skills needed to solve real world engineering problems; rather, it is expected these skills will be developed in design classes.

Our approach to classroom reform is using communication concepts derived from narrative in an effort to improve the flow of information in a class setting. Application of narrative in a learning environment offers the learner a more immersive and meaningful understanding of the material. There are several tools within the spectrum of narrative that can be used to deliver course content to students. Some of these tools are:

- Conceptual maps
- Social networking
- User created web content

- Video & audio content
- Hyperlinked content
- Traditional narrative reflection
- Real-world problems

These concepts applied to a college level engineering course, typically structured in the homework/lecture paradigm (Foertsch, Moses, Strikwerda, & Litzkow 2002) introduce new mediums for communication, interactivity, and added context. This is beneficial for the student in that they are able to access course information in ways that are meaningful to their personal learning style.

3.2 Background

Narrative is the representation of one or more real or fictive events communicated by one or more narrators to one or more narratees (Prince 2003). Narrative can be described as the way in which we as humans communicate; through the recount of events we are able to share knowledge, entertain, and collaborate. Often referred to as a story, narrative is a more comprehensive and inclusive term than story. While every story is a narrative, not every narrative necessarily meets the conventional notions of a story as a well wrought tale plotted with a sense of a clear beginning, middle, and end (Prince 2003). Narrative refers to both the story; that is, what is told, and the means of telling, implying both product and process, form and formation, structure and structuration (Potteiger & Purinton 1998). The story contains the content of what is being told such as characters, events, and settings. The discourse or, method of expression, is manifest as verbal or written communication, film, dance, or areas of design such as landscape and architecture. The story combined with the discourse creates a complete narrative structure.

Walter Fisher, narrative theorist, developed the Narrative Paradigm, which states that humans communicate through narrative and therefore experience and comprehend life through a series of ongoing narratives (Fisher 1987). The narrative paradigm sees people as storytellers; that is, as authors and co-authors who creatively read and evaluate the texts of life and literature. A narrative perspective focuses on the idea that existing institutions provide "plots" that are always in the process of re-creation rather than existing as settled scripts. Viewing human communication narratively stresses that people are full participants in the making of messages, whether they are agents (authors) or audience members (co-authors) (Fisher 1987).

The creation of narrative tools should support the three things needed for meaningful learning to take place summarized by Novak (Novak 1998):

1. Relevant to prior knowledge. That is, the learner must know some information that relates to the new information to be learned in some nontrivial way.
2. Meaningful material. That is, the knowledge to be learned must be relevant to other knowledge in related areas and must contain significant concepts and propositions.
3. The learner must choose to learn meaningfully. That is, the learner must consciously and deliberately choose to relate new knowledge to knowledge the learner already knows in some nontrivial way.

As stated above it is important to define the relationship between prior knowledge and new information. To help illustrate this relationship a concept map can be used. A concept map, if created by a student, can be a useful tool throughout a course. The instructor can help the students relate concepts in a form that makes the most sense to them by requiring the student to relate course ideas to existing knowledge (Ellis, Mikie, & Rudnitsky 2003). When creating concept maps in a computer environment, hyperlinks often provide the method in which the user navigates the map. Hyperlinks can help connect pieces of information by allowing the user the option to explore deeper into key topics.

Offering students a chance to solve real-world problems makes the material meaningful. These problems can be described through the use of audio and video content, thus giving the student a chance to see the problem in a much more immersive manner than with text alone. For use in engineering an example might be footage of a power plant paired with an efficiency problem. Requiring students to solve engineering problems with real world implications exposes them to the diverse situations and challenges that they will face as professional engineers (Berryman 1991).

Using web based communication tools aids in creating an environment where meaningful learning can take place. Web based social networking tools enable students to connect with peers that have similar learning interests. User created web content published in a Wiki allow students to define the layout of the course content as well as allowing students to quickly add outside content. This freedom of design encourages students to add their own perspectives to the content, thus allowing them to think critically about the material. A more common tool used in distance education and hybrid courses is the Internet forum. User generated content is posted in chronological order and under loosely organized topics. These tools provide the student with supplementary means to discuss and understand course material.

Communication and context are key parts of developing a comprehensive narrative. Each of these tools, used as part of a teaching strategy, should improve cognitive understanding of a subject by providing a virtual environment that encourages communication between students to solve problems, hence emulating the real-world work environment.

3.3 Implementation

Our initial trial for narrative based concepts were applied to a sophomore mechanical engineering course, ME 231, offered during the spring semester at Iowa State University. The course is an introduction to thermodynamics covering the basic laws of thermodynamics as well as the properties and processes for ideal gases and solid-liquid-vapor phases of pure substances. Until the spring of 2008, students enrolled in ME 231 had been taught with the homework/lecture paradigm (Foertsch, Moses, Strikwerda, & Litzkow 2002) in a traditional class involving lectures, quizzes, and homework problems. There were no small group labs scheduled for ME 231, which allowed very little in-class time for students to work on homework problems. A week's schedule includes 150 minutes of in-class time. The typical course might include 100 minutes of lecture, 30 minutes for quizzes, and 20 minutes for answering homework questions. Approximately half of the lecture time is used covering concepts and the other half to demonstrate example problems. This class model did not previously include supplemental web content or multimedia based instruction.

During the spring semester of 2008, there were 81 students enrolled in ME 231. Three of these were long distance students, and the rest were divided into two sections. The new class model has a format that includes 50 minutes of taped lecture per week and 110 minutes of class time. The time is split at about 60 minutes of example problems with student interaction, 25 minutes for answering homework questions, and 25 minutes of student problem solving. The majority of the time is still instructor lead, but students who have viewed the videos prior to class time are able to provide input for solving the instructor lead problems.

3.4 Website

As a means to host the video lectures and supplemental content, a website for the course was developed. The site was constructed using Moodle, an open source course management system. Moodle is based on socio-constructivist pedagogy by providing an environment that emphasizes collaborative interaction among students (Brandl 2005). Modules within Moodle use embedded HTML code to aid in content organization for the course webpage. Each of the optional modules has a defined function for the structure of the page such as a class calendar, forums, quizzes, and assignments. Additional content can be added by uploading user created HTML pages, text documents, and multimedia files.

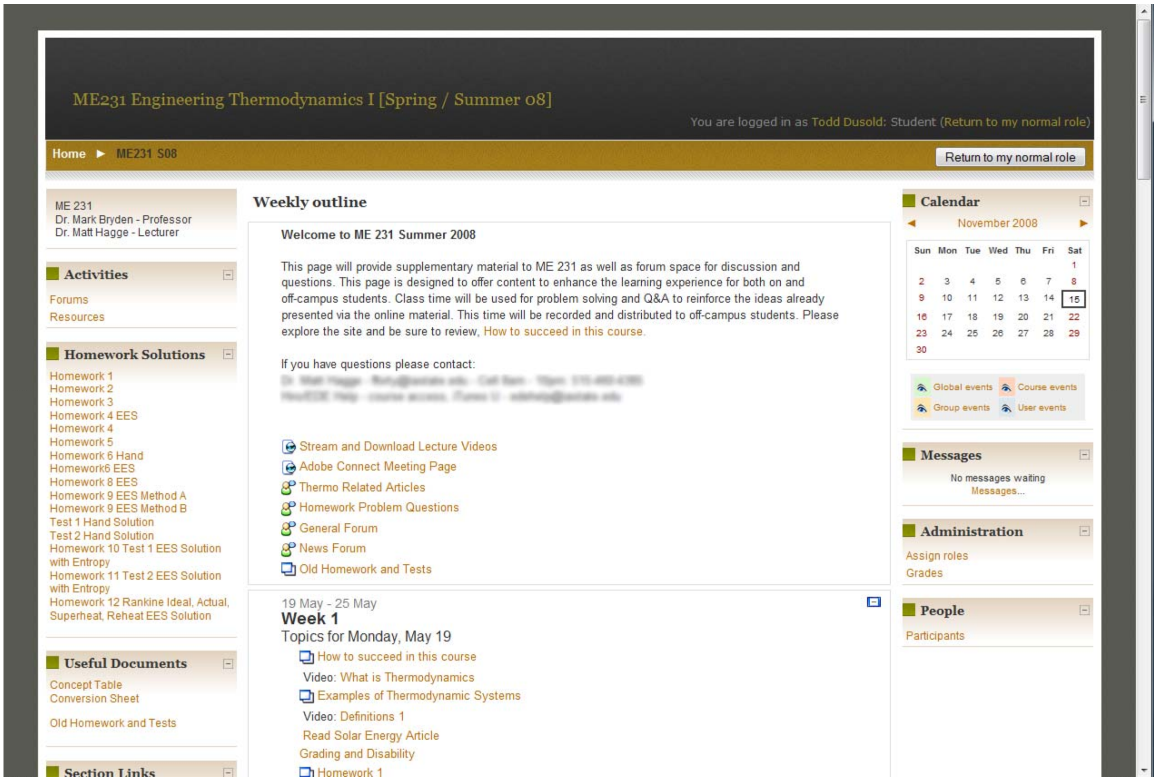

Figure 3.1 Course Website

3.5 Forums

Students were encouraged to use the forums provided on the course site as a means of asynchronous communication with their peers. The forums were divided into four sections: a news forum, general forum, homework forum, and a forum for posting external content related to thermodynamics. The news forum was restricted to postings only from the instructor. Its purpose was to inform students of important updates and events. The general forum was used to post questions in regards to the mechanics of the course such as how to download videos, where to post homework, and other general questions. The homework forum was intended to encourage collaboration among students to solve homework problems.

The course instructor provided needed guidance by checking this forum often. The forum for student added content provided a space to post articles, links, and videos that relate to thermodynamics, giving the students real world context for the course.

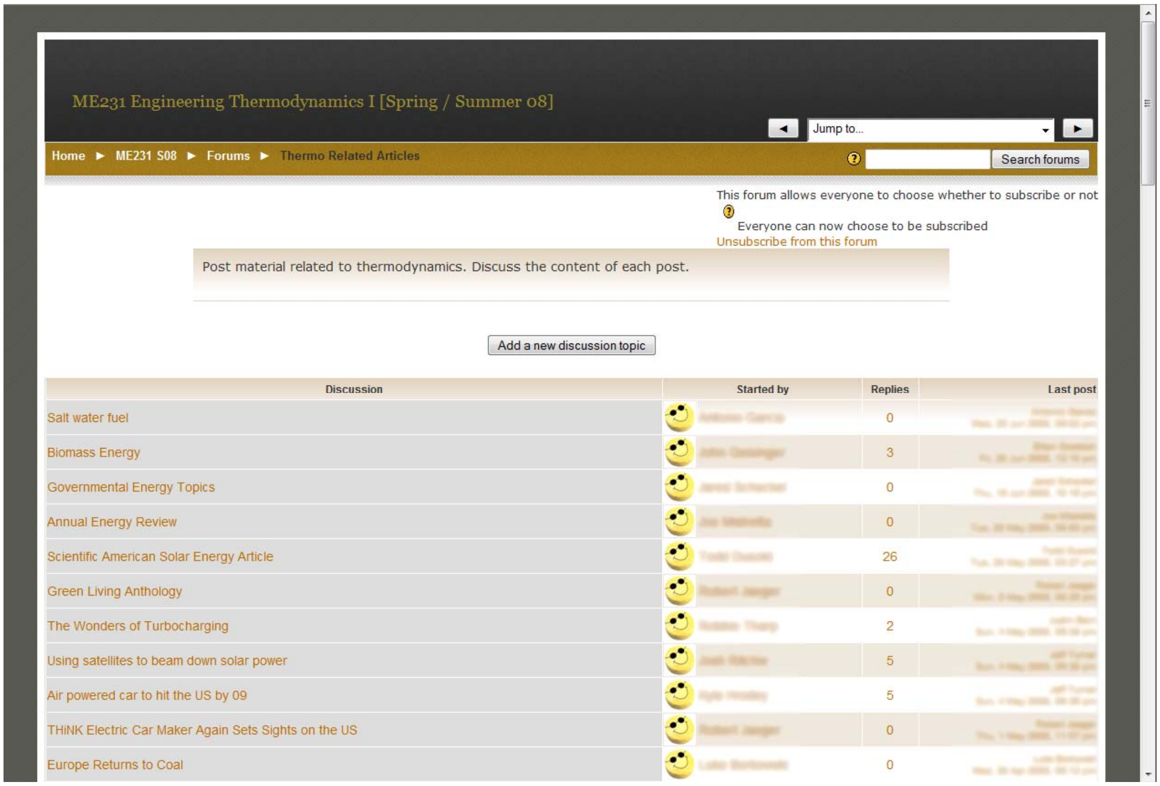

Figure 3.2 Course Forum

3.6 Video Lectures

The videos created for this course were unique in format and delivery. The video lectures were presented in 5 to 20 minute segments, each covering a different topic. The instructor would cover a topic on one segment then solve an example problem from that topic in a separate segment. This allowed the students easier access to topics of their choice because they didn't have to scroll though a longer video to find specific content. As a means of delivery, the videos were distributed to the students as podcasts through Apple's iTunesU music store. The section of the iTunes store containing the lectures was only accessible through a link on the course web page and not accessible to the general public. Given the growing popularity of podcasts, web video content, and mobile video devices such as Apple's iPod and numerous smart phones, podcasting the lectures was intended to offer the student a wider variety of means to view the video lectures.

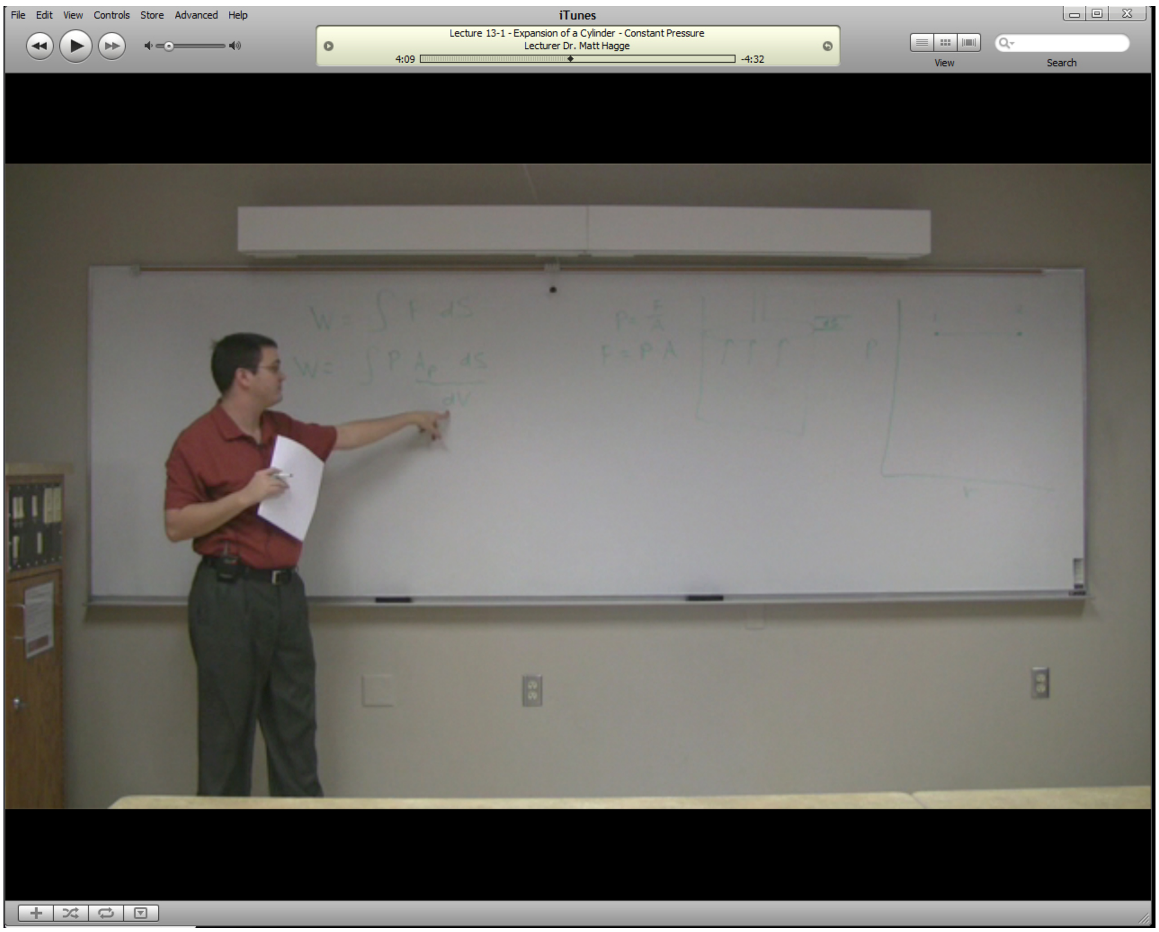

Figure 3.3 Lecture Video

3.7 Evaluation

The students of ME 231 were given two optional surveys, each asking questions covering a range of topics. The first block of questions was designed to determine if and how the students worked collaboratively. The second and third sets asked the students to rate the quality and content of the course videos and the course web site respectively. The last section of the surveys offered the students a chance to comment on their perceived positive and negative aspects of the course. The first survey was given at mid-semester and the second at the end of the course, both distributed through the course web page and completed online. The first survey was completed by 22 of the 81 students enrolled in the course, and 12 responded to the final survey. On average only 21% of the students responded; those who did provided comments useful to the further development of the course tools.

3.8 Conclusions

Using narrative in pedagogy is a difficult challenge for two reasons. First and foremost is the resistance of teachers to depart from the lecture and homework format that they are so comfortable with. The next challenge is to get students involved in active learning where they participate in the process. While this would seem like a boon to the students, it can be difficult to engage students in any activity that requires time or thought, both because the subject may not initially seem relevant to them and because of the demand from other coursework and outside activities. The teaching techniques described above will evolve to adjust for these difficulties through communication with course instructors and students. The evaluation techniques will be adjusted in each iteration of the course to help determine the source of uncovered flaws. The results of the student surveys for this initial trial of the course are given below for each aspect of the course.

Student posted content in the forums: The students posted content found in news articles and scientific journals relating to thermodynamics; most were on the topic of future energy sources. Initially the instructor placed an article in the forum that students were assigned to read. This article was discussed in class, but no points were assigned to posting or reading articles. Additional articles were found, posted, and read by students on a volunteer basis. As a final project students were required to choose a topic from this forum to research and then present their findings via a multimedia presentation. These activities were intended to help the students make outside connections to the material and thus increase their cognitive understanding of thermodynamics as a whole. Of the total respondents, 50% reported that the article activities were useful to their understanding of thermodynamics. Conversely 50% of the respondents did not make the connection between the posted articles and the course content.

Collaboration with other students: Group work was encouraged in ME 231, particularly on homework problems. At mid-semester 54% of respondents reported working collaboratively with other students. By the end of the semester this number had increased to 61%. Initially the class forums were used by 40% of students that reported working collaboratively; at the end of the semester that number had increased to 75%.

It is of note that the homework forum received several new questions each week and most received follow-up from students. However, compared to other methods of collaboration, working with other students in person was the preferred method. Of the respondents who indicated some form of collaboration, nearly 100% had reported doing so in person.

Video lectures: The majority of students, 77% in each survey, thought that the video lectures were useful to them. It is interesting to note that the audio and video qualities were both rated as sufficient by the vast majority. This suggests that a podcast lecture is a viable option for future content distribution in terms of quality. Although only 9% reported transferring the lectures to a mobile video device, it is encouraging that some students took advantage of the podcast format. Some of the students suggested dissatisfaction with the iTunes delivery method. This is likely due to the technical difficulties encountered near the beginning of the course. The web code to link students with the iTunes download page had bugs that have since been resolved; however students were unable to download lectures while the problem was being resolved. Lectures are now available via CD-ROM upon request as an alternative to the iTunes download.

Course website: Students typically accessed the course web page on a weekly basis. Over 90% of the respondents on each survey reported that the web page was easy to use. This rating is encouraging for future use of the Moodle course management software. At mid-semester 86% of the respondents reported the web site as useful to the course; by the end of the semester 99% reported the web site as useful. There are several factors that could explain this increase in approval; as the course progressed, more content was added to the page, both from the students and the instructor. Also, issues accessing the page and downloading the video lectures were resolved by the second half of the semester.

The final project: As with any project, there was a range of quality and level of enthusiasm from the students. At a minimum, this project allowed students to explore a topic that was of interest to them. Students were asked to provide some background of the topic, and to provide an analysis based on conservation of mass and energy, as well as the entropy equation. In general, students were able to write these equations quite easily but found the process of finding real numbers extremely challenging. However, most were successful. A sample project analyzing a coffee maker is located in the Appendix.

This hybrid version of ME 231 is in a stage of development and exploration. The course was chosen for this study with the intention to develop tools and techniques that would evolve the pedagogical structure of engineering education as well as expand engineering education at Iowa State into the distance education market. While the goal of providing material that students can explore and learn for themselves has been only moderately achieved in the first iteration, several useful tools were created to increase student's interaction and exploration through narrative. Future work based on the tools developed in this study will undoubtedly improve the student experience in future engineering classes.

3.9 Future Work

The introduction of a concept map would provide students with a resource to understand the concepts covered in thermodynamics. The key concepts were learned through video and in class work, but a complete, hyperlinked, concept map has yet to be created for the material. Some course content such as definitions and explanations of key concepts was created on the web as basic HTML pages for student reference; however, this written material is not complete at this time.

Improvement in production quality of the lecture videos is a priority as they are the single most important source of information for the course. Currently the videos feature the course instructor giving a typical lecture using a white board. Students reported trouble viewing the writing on the white board and occasional sound issues. Solutions could include the use of a digital text display embedded in the video and a properly recorded sound track. In order to improve the narrative within the videos, shooting on location at relevant places of interest would help in exposing the students to real world problems. An example could be video footage of a power plant while discussing its issues and applications of thermodynamics.

CHAPTER 4. CONCLUSIONS AND FUTURE WORK

There are numerous ways to define narrative and only a very few have been described in the previous chapters. It can be a very broad term containing every factual and fictional story that human history has to offer. Narrative is part of the very core of human culture and, as such, has been defined in many ways and in as many languages. Narrative can also be a very narrow term, used to describe literary writing structure or the rise and fall of action on a playwright’s stage. A common thread in all descriptions is that narrative is a story. It could mean the story structure, part of the story or the story itself. Because stories are an important aspect in culture used for communication, entertainment and the recall of our own memories, the most comprehensive definition may be that narrative is the means that we as humans use to communicate.

Research of narrative in the engineering field is limited at best. The need for improved communication and understanding is driven by increasingly complex projects. Networked computers and increased processing power are excellent tools in engineering design but can result in overwhelming amounts of information. Organizing this information into a narrative has several benefits including:

- Increased cognitive understanding
- Efficient decision making
- Added context to data
- Historical reference

These benefits will enable improved communication among design teams consisting of multiple engineering backgrounds. As the complexity of projects and design teams increase, further investigation into the application of narrative has become necessary. Proof of concept in engineering software will likely be the next step for this research.

Narrative is common in the classroom environment. Stories are used to teach math problems, Shakespeare is read aloud and discussion aids in retention. However, in collegiate engineering courses narrative has remained relatively uncommon. A modified pedagogy, as described in Chapter 3, was able to show that stories could help the student in adding outside context to otherwise purely computational data. Also, providing an environment where communication with peers is encouraged enables students to help one another with the material. It is context and communication that provide a better emulation of the real world working environment. Moving this research forward can take place in several areas. Using concept maps as a supplement to the material would potentially aid in relating course topics to each other. Increased exposure to real world problems in lectures and homework would help students understand relevancy in course topics. Exploring new means of information delivery for the course will increase student exposure to the material. The addition of dynamic content, including video and interactive activities, gives the students an opportunity to explore more methods to access the course material.

There are many approaches for using narrative in education, design or any other field. Although there are an infinite number of possibilities, they all share the same motive; they help people communicate and understand. Several approaches have been discussed in this research with various levels of success. Further investigation of narrative to better understand the complexities of human communication, in addition to exploring new methods of narrative delivery, will expand the available means for conveying information and will facilitate future research.

A future approach to narrative lies in graphical representation of complex data sets. Most of the engineering design process takes place in a computer-based environment. These environments enable rich information visualization giving the user additional perspectives on the data. To increase the level of user comprehension, a narrative can be created by placing the initial visualization in the context of its real world environment. For example, a data set representing the heat properties of a cook stove can be displayed in numerical and color-coded visuals. This data can be placed into context by overlaying the graphical information over a visually accurate representation of the stove. The benefit is the ability to quickly communicate complex data to project team members as well as lay persons. Results in numerical graphs can be explained; however, it is much quicker to show a visual representation of the object. In the case of a stove, people are able to see that the red overlay on the stove is the highest temperature on the surface and blue is the coolest. This concept can be applied to most engineering design projects because each needs to display a representation of a physical object that exists or will be constructed. Expanding this concept will require further understanding of how narrative affects live graphics and visual imagery. The concept will no doubt evolve just as the understanding of narrative is always evolving, and its application to the field of engineering is only beginning.

APPENDIX

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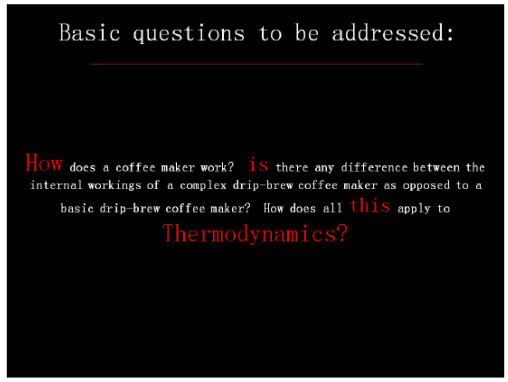

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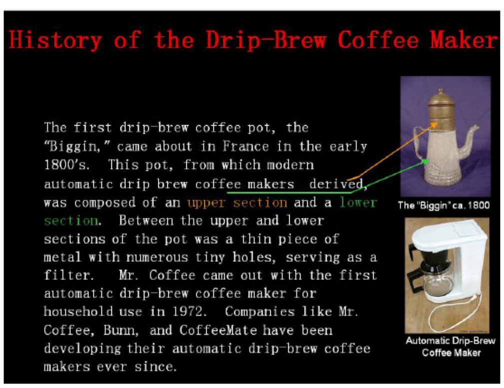

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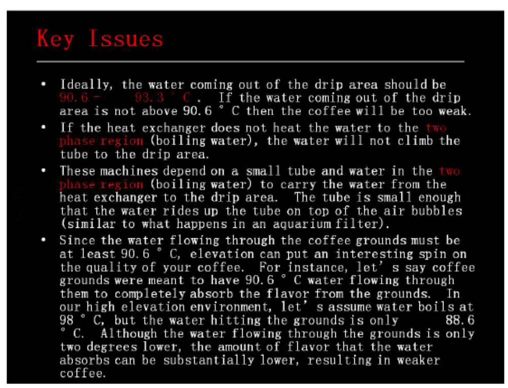

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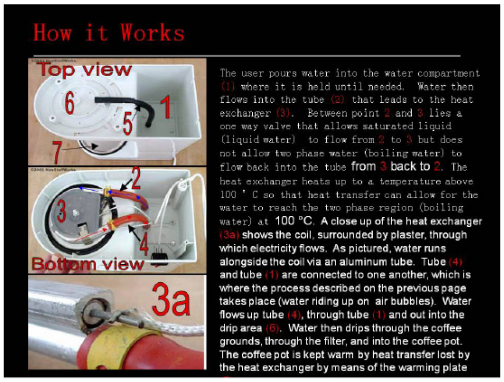

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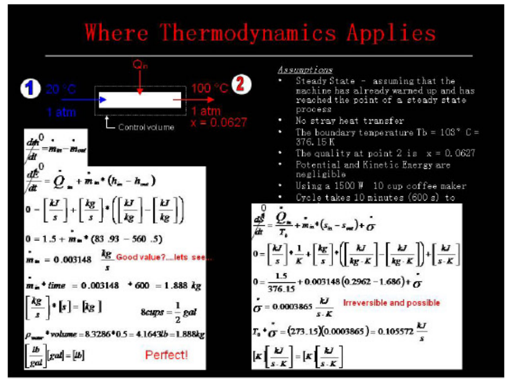

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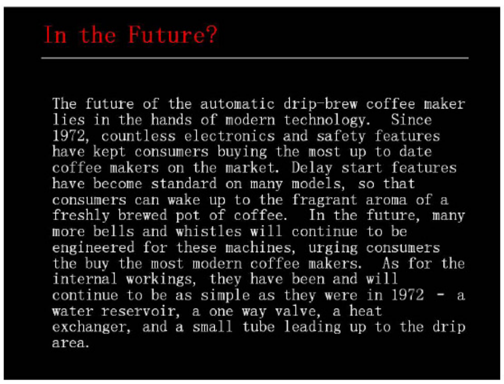

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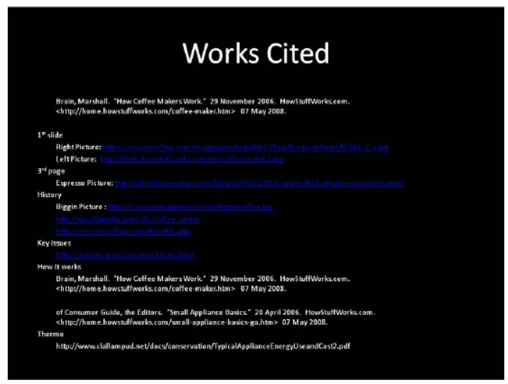

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