Using Stories of Technology to Teach Technological and Engineering Literacy in Courses for Majors

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Abstract

To help them function in society, all citizens need to have some understanding of engineering and technology. In colleges and universities, this need should be met as part of the general university core curriculum. Accounts from the history of technology, stories told by engineers and by users of technology, and news items can all be useful in teaching people about engineering and technology.

While efforts to educate all citizens have been focused on people who are not studying engineering, our majors also need to be considered. For students preparing for careers in engineering, stories can show the human side of engineering and technology along with elements of engineering practice. They can be used to cover important elements of engineering that do not come across in courses that emphasize engineering analysis or practical experience with a given technology. Stories that can be used to tell non-majors about engineering and technology can also be used to show our majors why their course material is important and how it can be used. These accounts can be used to put the material in the larger systems context.

In a traditional classroom setting, stories are often told in lectures. Faculty are currently being urged to lecture less and have students explore and learn more through their own efforts. Stories can be presented in reading assignments. With online resources, it is relatively easy to use shorter readings focused on specific points. If online readings are used, the instructor can use excerpts from many sources instead of the few books students can reasonably be expected to purchase for a course. The readings can be easily put together with required activities, such as online questions to be graded automatically and discussion boards.

This paper will discuss a work in progress to develop a set of stories in the form of online reading assignments to help students understand more about engineering and technology. The goal is to develop a collection of engineering story units that can be used in courses ranging from an introductory course for first year students in the major to upper level and graduate courses in areas such as thermodynamics, machine design, and systems engineering. These units should include online question sets, discussions, or other activities that require the students to make use of the material, should be classified by aspects of engineering and technology, and can be selected and used to support different courses. These engineering and technology story modules should be useful not only in courses for our majors but also in engineering and technology courses for non-majors and in courses in other areas such as economic history and business. Pilot modules are currently being introduced in courses; this paper will report on progress to date and lay out plans for future work.

Introduction

Technological and engineering literacy (TEL) has been recognized as a critical need [1-3], and much work has gone into efforts to define and teach these subjects [4-9]. While much of this effort at colleges and universities has been focused on non-majors, people graduating from

engineering and engineering technology degree programs cannot just be assumed to have this literacy. TEL needs to be incorporated in the engineering curriculum as well [10-14].

Classes for majors focus on specific subjects in engineering and technology. The material must be covered, and students are to be evaluated based on their ability to demonstrate the use of the specified material. A first course in thermodynamics, for example, is expected to cover certain material. On successful completion of the course students are expected to be able to demonstrate knowledge of this material by solving problems. As students move through the degree program, they are expected to demonstrate competence in labs and in project work.

There are aspects of engineering and technology that are not well represented in this process. In classes that emphasize using specific tools to solve specific problems, evaluation is often based on set-piece problems. Students will know going in that they will be evaluated on material covered or applied in the course and that they will be given sufficient information to apply the tools from the course to solve the problem. This focus is appropriate for the specific material of the course, but it misses how and why one gets to the point where the course material is needed. It also misses more general aspects of engineering and technology. Courses with project work move beyond this to some degree, but are unlikely to succeed in covering some facets of technological and engineering literacy (TEL).

Many approaches have been documented for teaching technological and engineering literacy [4, 5]. A search for technological and engineering literacy in the ASEE PEER database in February, 2019, resulted in a list of 60 papers from technical sessions of the Technological and Engineering Literacy/Philosophy of Engineering (TELPhE) Division alone; 163 are listed for technological literacy from this source. The use of stories for teaching TEL is reported in many papers; papers by Loendorf [15] and by Halada and Khost [16] specifically mention stories or narratives. A recent paper by Heywood and Lyons [17] uses an account of the Grenfell Tower fire to illustrate points about the need for TEL.

Goal of This Work

The goal of this effort is to develop a collection of stories illustrating aspects of engineering and technology for use with engineering technology and engineering classes. While the current focus is on courses for majors, these TEL stories are expected to be useful for a technological and engineering literacy class for non-majors. They should also be useful for bringing TEL into classes in other fields, such as a course in economic history.

This content should give students insight into aspects of engineering that often are not encountered in traditional engineering courses such as:

- The thought process; inspiration, creativity, and working through problems,
- What comes before the use of the material in the course or curriculum? Or … how does one get to where the problems in the course begin?
- Where do design parameters come from?
- What comes after the use of the material in the course or curriculum?
- The broader picture of systems and systems engineering,
- The people side of engineering internal to the organization, and

- The people side of engineering and technology – how people accept, learn to use, and are affected by engineering and technology.

The stories should help students develop the characteristics of a technologically literate citizen given in Technically Speaking, especially in the areas of Knowledge and Ways of Thinking and Acting [18]. For example, a story may give examples of constraints or trade-offs, or of how people influenced or made decisions about a new technology. They should help students appreciate the questions to be asked about technology given in that source as well, such as the risks of a new technology or the effects of not adopting a new technology [19]. These should also be linked to aspects of technological literacy identified in ITEEA standards [3].

The stories are to be delivered in writing as a series of short, online readings accompanied by questions that will serve to help students see the point(s) of the assignment. The questions should also provide an incentive for students to read the assignments. With this format, these assignments may take the place of stories told in lecture, freeing time for other work in the classroom. They will also provide a way to include this material in subject area courses like thermodynamics where there is limited time in the classroom for material of this sort. The online environment should provide better options for assessment.

Including these items as part of the course material will serve to add technological and engineering literacy (TEL) content to subject area classes for majors.

As the immediate focus of this work, stories have been and are being developed for classes that include the department's first year course for new or prospective majors, undergraduate subject area courses such as thermodynamics and machine design, and an engineering problem solving course for upper level students. They may also be used with a graduate courses in the future. The assignments produced should be appropriate for other areas of engineering and technology and for courses for non-majors.

Technological and Engineering (TEL) Stories

As planned, these are to be in the form of short readings assigned at regular intervals. On average, at least one assignment would accompany other class material each week; ideally, there would be one assignment to go with each class meeting. The target length for each item is 1-2 pages. Each installment should bring out some specific aspect(s) of engineering and technology.

These are being set up as online assignments. They should include questions or other work for the student to do after reading the story. Depending on the content, the class, and what students are expected to do with the material, the assignment may be followed by discussion in class. The latter would fit the form of the inverted classroom where material is presented online and students are expected to use the material in the classroom.

For this effort, written accounts such as the autobiographies of engineers, books on engineering topics written for a general audience, and accounts by users of technology are sources for stories. News items, personal experiences, and fiction could also be used.

Each assignment should illustrate specific aspects of engineering and/or technology. A short summary of these aspects – the takeaways of the stories – should be developed for each story or installment.

For each story there should be something required of the student. These activities should help the student understand the material. At a minimum, this may be a short online quiz. As this would be part of their class grade, it gives the students an incentive to read and take in the material. To give prompt feedback and to keep the workload manageable for the faculty member, these should be graded automatically. As the primary goal is to help students understand the material, it may be useful to allow them to repeat the quiz. Other exercises, such as classroom or online discussions, may also be included.

While these assignments may be supplemental to the primary course material, this material should be covered on the exams. This is likely to be a small part of the course grade, but including it as part of the grade will encourage students to do the assigned reading and to see this as something important.

The stories should be relatively easy to read and understand. Finally, they should be enjoyable.

How Is This Different?

Stories have long been part of class lectures. For these to be effective, students have to pay attention. The student may not be asked to make use of the material until later. Even if the student was attentive, they may not have understood or even recall that part of the lecture. A short, written story presented as an online reading assignment with questions linked to the story has the potential to reach students with greater effect. If students prefer to take in information by reading material on a screen instead of listening to someone talk, this puts the content in that format. Questions linked directly to the story can help students see the point. Also, the online questions can be used to directly link the material to their grade in the course.

One could assign an article or a book as part of the course readings. However, the student must do the readings and then must sort out the important topics. The intent of the short reading format is to make it more likely that the student will read the material and that they will see the specific point(s) of the assignment. If these assignments are added to a course where the workload is already heavy, a short reading assignment is more realistic to add to the workload. Also, with this format students will not have to use reserve materials or purchase additional books.

Case studies are very useful for covering many of these facets of engineering and technology. However, case studies are often substantial pieces of work. The goal here is to create something shorter that can reasonably be added to supplement current course material in small pieces. The social media Twitter is an inspiration for these stories, even though a tweet is limited to a few sentences and the target length here is 1-2 pages. The goal is to keep the individual items short so that, as additional work on top of other class assignments, this will be beneficial without taking too much time. These are not intended to take the place of the case study, but are intended for use either to supplement a case study or where it is not feasible to add a case study to the course workload.

At the author's institution, there is a push for faculty to redesign classroom courses as hybrid classes where up to fifty percent of the class is run as an online course. Illustrative stories in this form provide content for the online part of the course. Online stories fit the inverted classroom model of instruction. With the story presented online, classroom time can be spent on discussion and other applications of the material.

To summarize, the project goals are to:

- Develop a collection of stories that illustrate aspects of technological and engineering literacy to help students develop the characteristics of technologically literate citizens,
- From these stories create short reading assignments tailored for online instruction,
- Develop questions to accompany each item that will help students understand the point(s) of the assignment,
- Use these online assignments to add or enhance the teaching of technological and engineering literary in courses for engineering or engineering technology majors, and
- Use results from questions, both those accompanying the stories and later on examinations, to assess and evaluate the student's development of engineering and technological literacy.

The desired results are 1) to help students develop engineering and technological literacy, 2) in courses where stories are already used move this to what should be a more effective method of instruction, 3) to add this content in courses where this is generally not included, and 4) to provide an opportunity for assessment of TEL.

Progress to Date:

This is a work in progress. Some stories have been developed and used in classes; more are being developed. Stories have long been part of lecture content for the first year course. As a step towards moving this part of the course online, online content has been added to supplement the stories, and the stories are told in an abbreviated form in the class.

Two sample stories which were used in courses in the Fall, 2018 term, are presented here. As a work in progress, my vision of what should be included in each assignment has changed. Some stories presented here need a round of revision to fit the model described in the previous section.

Sample TEL Story No. 1

The purpose of this story, taken from Gordon [20], was to give students a reason why design analysis and calculations are important and what they tell the engineer. Additional material on loads and structural failure was included to help students understand the story.

This was used with the first year class and would be useful with classes for non-majors. It would also be useful for classes where load calculations are taught, and will be used at the start of an upcoming class in machine design. The short answer questions were taken directly from the course online (Desire to Learn – D2L) site. The questions are simple; they do not go into any depth, but they do have the students do something with the material. Also, they do give the instructor an indicator that the student did something with the material.

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Why We Don't Just Build Things – Why We Do Calculations & Analysis First

Engineering education includes courses where you are taught how to set up and do design calculations. For example, students preparing to go into the fields of civil and mechanical engineering will take a course in statics, where they will break apart a design on paper and determine the forces acting on each part of the structure.

In case you were wondering why you have to learn to do this …

In his book on materials, J. E. Gordon tells the following story from the early days of flight.

> *It is generally a mistake to despise any form of construction and this certainly includes the "stick and string" biplane. …. The biplane form enabled efficient lattice girders and also an efficient torsion box to be achieved in a very robust form with little weight. … Solid members needed only to take compression …. tension members could be simple piano wires ….*
>
> *This philosophy produced strong and excellent aeroplanes so long as one was quite sure which members were in tension and which in compression, for, though a strut could at a pinch take tension, a wire could not take compression. …. S.F. Cody, of the "Cathedral" biplane, was addicted to elaborate rigging …. My grandfather, who was one of the aircraft pioneers, told me that he had a long argument with Cody about whether a certain member was in tension or in compression in flight. Cody maintained it was in tension and had provided a wire. It turned out my grandfather was right for Cody was killed just a few minutes afterwards for just this reason.*

Gordon adds …

> *By some kind of irony this was exactly the reverse of the trouble with masonry cathedrals which fell down because they turned out to be in tension when the builders held that they were in compression.*

Done correctly, those design calculations can tell you which parts are in tension and which are in compression.

Source:
Gordon, J.E., the New Science of Strong Materials, or Why You Don't Fall through the Floor, Princeton University Press, 2nd Ed., 1988. pp 162-3

Notes on Engineering Terms:

Tension — where a force is applied that **pulls** on an object. If you are pulling something with a rope, you are putting the rope in tension. By convention this load has a (+) sign. The part is likely to fail by breaking in two.

Compression — where a force is applied that **pushes** in on an object. If you stand on a concrete block to reach something, you are putting the concrete block in compression. By

convention this load has a (-) sign. For long, slender parts, the part is likely to fail by buckling.

Torsion — **Twist**. When you unscrew the top of a jar or a drink container, you are applying torsion to the top. If you put enough torsion on the top, it will unscrew and come off. If when you put the top back on you apply too much torsion, someone else who cannot apply as much torsion will not be able to open the container. This will not make you popular.

Aside: You are pulling a wagon. If the wagon has a handle that is anchored at the other end, you can pull (tension) or push (compression) on the handle and move the wagon forwards or backwards. If the handle is replaced by a rope, can you **push** through the rope to move the wagon?

Further Reading:
Do a quick online search for more about Samuel F. Cody, his airplanes, and his last flight.

Questions:

In early airplanes, every piece of the structure was made to take loading in both tension and compression.

- True
- ➡ False

A structural design calculation shows a force of -5000 N (a negative value, in case the minus sign isn't big enough) acts along the axis of a part in a structure. The load on this part puts it in ...

- Tension
- ➡ Compression
- Torsion

A long, slender structural part is in compression. It is likely to fail by ...

- ... being stretched or drawn until the part becomes too long and the cross section narrows.
- ... breaking in two.
- ➡ ... collapsing with a bend in the middle, otherwise known as buckling.
- None of these

If the designer fails to plan correctly for the load acting on a part, the structure may fail and people may be injured or worse.

- ➡ ● True
- ○ False

***

This was used with two sections of the introductory course in the fall of 2018. This was posted in two parts; the story was posted under the Content tab and the questions were posted under Tasks as an online quiz. The quiz did show that many but not all students in both sections did give answers to the questions. A question about this reading was included in the online portion of the final exam.

The questions should be revised to give a better assessment of student understanding. True-False questions should be replaced with questions where it is more difficult to guess an answer.

Sample TEL Story No. 2

This story, taken from Maxim [21], was included as both a story of inspiration and vision and as a story of the initial stages of development of a new technology. It is intended as the first installment in a series based on his account of how he, with no prior expertise in the field, went through a process of study, trial, and error and succeeded in creating an automobile that went into production. It is also intended as the lead-in to other stories about the necessary infrastructure. The need for roads is mentioned in the last passage; assignments showing the need for support for the new technology in other areas, such as access to repair services, fuel, tires, etc. would follow from this as well.

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Some Lessons in Engineering from the Early Days of the Automobile.
Hiram Percy Maxim

Hiram Percy Maxim was an early pioneer in automobile technology in the United States. In the early and mid-1890s, Maxim made a vehicle powered by an internal combustion engine burning gasoline. He went on to be one of the very first people in the United States hired as an automotive engineer, and he developed electric and gasoline internal combustion automobiles. Decades later, he wrote of his experiences. [Note: this is not the Maxim of Maxim gun (machine gun) fame. That Maxim was his estranged father.]

Maxim - Inspiration:

> *Late one summer night in the year 1892, as I was pedaling my bicycle along a lonely road between Salem and Lynn in Massachusetts, the thought came to me that it would be a wonderful thing if a little engine were to be devised which would furnish the power to drive a bicycle. A little engine which would do what my legs were doing did not appear such a serious problem. I could not be expending more than a sixth or a quarter of a horsepower, and that would not mean much of an engine.*

> *I had been spending the evening with [a] young lady in Salem. …. my thoughts were quickened on that lonely ride that night.*
>
> *I thought about transportation. …. The bicycle was just becoming popular and it represented a very significant advance, I felt. …. My bicycle was propelled at a respectable speed by a mechanism operated by my muscles. It carried me over a lonely country road in the middle of the night, covering the distance in considerably less than an hour. A horse and carriage would require nearly two hours. A railroad train would require half an hour, and it would carry me only from station to station. And I must conform to its time-table, which was not always convenient when calling upon [a] young lady in Salem.*
>
> *If I could build a little engine and use its power to do the propelling, and if I could use a regular carriage instead of a bicycle, there would be no limit to where I could go. Distances would be halved. Towns would become nearer together. More people would intermingle. It would profoundly influence the course of civilization ….* Maxim, Horseless Carriage Days, pp 1-2

After noting that he was unaware of work being done by others at this time, Maxim observes that …

> *It has always been my belief that we all began to work on a gasoline-engine-propelled road vehicle at about the same time because it had become apparent that civilization was ready for the mechanical vehicle.*
>
> *The reason why we did not build mechanical road vehicles before this, in my opinion, was because the bicycle had not yet come in numbers and had not directed … minds to the possibilities of independent, long-distance travel over the ordinary highway. We thought the railroad was good enough. The bicycle created a new demand which it was beyond the ability of the railroad to supply. Then it came about that the bicycle could not satisfy the demand which it had created.* Maxim, pp 4-5

Discussion Question: Maxim wrote this about his thoughts in 1892. How did his predictions in the last paragraph turn out?

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As this is intended as the first installment in a series of stories, only one discussion question was included in this initial use.

For the first example, the majority of students in both classes answered the questions. There was limited discussion of the second story in the classroom. Questions on this assignment were also included in the final exam. The scope of the questions was limited and they were but a small part of the online portion of the final exam. Beyond having some evidence that students did answer questions successfully, there is very little evidence for evaluating the effectiveness of these assignments.

During the spring, TEL stories have been used in thermodynamics and in machine design classes. While the introductory course sections discussed previously were populated largely by students in their first semester, students in these courses have more academic maturity and have gone far enough in the degree program to be likely to succeed. In our engineering technology program, thermodynamics is a required course taken by 3rd and 4th year students. This was assigned late in the course, and the students were given extra credit on the final exam for the questions accompanying the story. Here the assessment results were quite good for the short answer questions based directly on the story.

Continuing Work

Two sample narrative assignments have been presented here; others have been prepared and are being used with classes. For example, a set of passage taken from the autobiography of Sir Stanley Hooker of Rolls Royce [22] was used with a thermodynamics class. Prepared in installments, this tells of his transition from academic applied mathematics research in compressible gas dynamics to the engineering work of improving the design of superchargers for aircraft engines. Applying his knowledge, he was able to recommend improvements that resulted in a significant increase in the power output of the Merlin engine and, in turn, aircraft performance. This illustrates the value of theoretical work in engineering and why an engineer's curriculum includes higher level courses in mathematics and engineering science. While this shows what Hooker could do with his unique background, Hooker writes about what he did not know and his account talks about the importance of the people who knew what he did not know and could act on his recommendations and create and manufacture a practical device. An installment from this series on the work of the designer is relevant to a class in solid modeling software, as it should give students a better understanding of how this software is to be used and how engineering practice has changed with the introduction of this software.

Joe Sutter's autobiographical account of the development of the Boeing 747 [23] contains a number of stories about working with the customers and about the dynamics of his engineering team. For example, Sutter's description of selling the lead customer (Pan American World Airlines – Pan Am) on a different layout than what Pan Am's executives insist that they want will help to show students an aspect of engineering work that they are not likely to encounter even in their capstone project classes. Sutter had a very good team but one where some of his principal engineers found it difficult to work together; Sutter's description of how he managed these problems should help prepare students for the workplace. In terms of the courses taught by the author, the primary uses for these passages will be in the first year introductory course (next offering in Fall, 2019) and in the upper level engineering problem solving course (next offering scheduled for Summer, 2019). They would be quite useful with a course for non-majors, and at the other extreme some may be used in a graduate systems engineering course at a later date.

The two samples presented here and the other stories mentioned as having been or being under development have been planned with specific courses in mind. However, most if not all would be useful in a class for non-majors. The TEL stories are not intended to teach subject matter requiring math or other prerequisites. Rather, these stories are intended to focus on the qualitative side. For example, Hooker's description of the design engineer would be at least as

useful to a non-major who may need to understand how engineers work as to a student majoring in an engineering field studying design tools.

Observations Based on Work to Date and Future Work

TEL stories fitting the framework discussed in this paper have been selected, prepared, and have been used with classes. They have been used with classes at the introductory level that have parallels with courses for non-majors and in subject-area classes for majors. More are being prepared. To date, the use of assignments and the assessment of learning has been tied to the specific courses.

Sources for suitable TEL stories are widely available. In reading accounts of engineers and their work, the author has encountered suitable passages in abundance; it has been more of an issue to keep track of useful passages and to prepare the assignment.

While repeated use in more than one course is appropriate and may even be desirable, the collection needs to be much larger to avoid undue repetition. The collection of prepared stores and of materials for creating more reflect the author's interests and biases. The author is drawn to technologies from the mechanical field such as water and steam power, railroads, automobiles, and aircraft. Students may not share the author's interest in the Concorde SST, for example, and it would be useful draw from a broader range of technology. With an initial pattern established, this should become a collaborative effort in the future.

The author approached this thinking that some tasks would be fairly straightforward: categorization, producing the stories, and preparing questions.

For categorization, the author envisioned using the dimensions of technological literacy from Technically Speaking [1] as a starting point. The author also envisioned categorization by course and subject matter. Some items have machines as their focus, others still are related to more general aspects of design or of engineering practice, such as dealing with the customer or client. In practice, while each narrative has its point, setting up useful categories has proven to be more complicated. More needs to be done to develop a comprehensive classification system.

The expectation was that, once a passage was selected, it could be presented with minimal additional content. In most cases more material has been needed to put the passage in context. That has its benefits; for example, in the sample story from Gordon, additional material on engineering terms and concepts fit nicely with the piece and contributes to the TEL mission. However, this does add to the work required to prepare an assignment.

For each item the author envisioned creating an online quiz consisting of a few short answer questions, and that the student could only do well on the quiz if they had read the assignment. In practice, this has proven to be a challenge. It is easy enough to write short questions focused on specific points. The author has been concerned that multiple choice and other question formats that can be set up for automatic grading online are often such that the student can guess the answers without reading the story. While the student may still get some of the content if they at least read the question before making a guess, this defeats much of the purpose. This is a

concern, but this should be compared with including this material in a classroom lecture, where the student may not be paying attention or even present.

To date the questions used for assessment have been simple and focused on the narrow details of the specific narrative. This fits the requirements for auto-grading, but it only goes so far. Discussion after the initial assignment, either in class or online, should help students understand the material.

One question in assessment is whether presenting stories as online reading assignments is more effective than presenting the material in a lecture. With the next series of large introductory courses in the fall, enough online assignments should be ready so that enough exam questions can be used to cover both formats and to see if there are any differences in results.

More difficult still is the challenge of producing questions that give a proper assessment of technological and engineering literacy. Questions focused on individual reading assignments may cover specific points but will at best give only a limited indication. With a series of assignments in an individual course, comprehensive assessment of TEL should be performed both at the beginning and near the end to show progress in developing TEL during the course. Better still, with assignments of this type used in several courses, perhaps at different points in the student's academic career, an assessment should be made at the start and again in the final year. The subject areas for questions in this comprehensive assessment should relate to the areas in the classification system. As this is a work in progress and the focus of work to date has been to develop stories, the assessment performed has focused on what students have understood from the specific assignments. With more assignments developed and in use in courses at different levels, a more comprehensive assessment of TEL will be possible and will be pursued.

There are several areas where collaboration would be highly beneficial. The author's experience in teaching is primarily in engineering subject area courses with largely quantitative material, while the material covered here is more qualitative in nature. The author's use of stories draws from following the pattern observed in the classroom and not from literature on the subject. Assistant from people with greater expertise in making effective use of this sort of material and in developing instruments to assess learning with qualitative material would be welcome. For the online environment, the author's institution has instructional designers who can help improve that aspect. At this point, the goal has been to get something in place. Efforts at collaboration with experts in instructional design will be most productive with something in place to critique and to improve upon.

While the stories being developed will serve the author, it would be desirable to make these available to others, and for others to develop similar and share stories as well.

Another area for future collaboration is with other faculty with expertise in this field. The author has enjoyed two opportunities to be part of an interdisciplinary instructional team with faculty colleagues from history and from philosophy. Faculty from business, history, and other fields with an interest in engineering and technology have much to contribute to this work. Interdisciplinary collaboration in creating these narrative assignments would bring in other perspectives and improve the result. There is also room for other engineering and engineering

technology faculty to contribute. For example, someone else would be better equipped than the author to prepare a module based on a story related to i-Phone technology. The result would be a story related to the device the student may be using to read the assignment. No topic will have the same appeal to all students; a mix of topics such that there should be something to appeal to students with different interests would be helpful.

Conclusions

A project to develop short, online reading assignments to help students develop technological and engineering literacy (TEL) has been launched. The first of these assignments have been used in classes at the first year and at the upper division level. The work to date is a step towards developing a collection of assignments linked to specific aspects of TEL suitable for use in classes for majors and non-majors. These should be useful in efforts to infuse TEL into the curriculum for engineering and engineering technology majors, and should also be useful in classes for non-majors. Work is continuing in the areas of producing and categorizing assignments and in developing effective tools for comprehensive assessment.

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