Equipping First-Year Engineering Students with Artificial Intelligence Literacy (AI-L): Implementation, Assessment, and Impact

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Emergence of AI in Higher Education

While artificial intelligence (AI) has existed in some form since the 1930s, the pace of advancements has accelerated significantly in the last decade. Modern AI is rooted in Alan Turing's theory of computation, which defined the "Turing machine" as a set of logical rules that could, generally, be used to compute solutions to nearly any problem [1]. The set of logical rules known as the Turing machine later developed into the concept of neural networks, the backbone of most AI technologies today. Many major AI tools today are pre-trained to use a neural network to decipher a specified dataset; this automated process is called machine learning. This paper will centers on application of a subset of machine learning AI called deep learning, which requires a much more complex neural network and often uses expansive sets of data. In particular, this research focuses on use and literacy of this type of artificial intelligence for text-based processing, or language artificial intelligence.

Much of the discourse regarding language AI in recent years focuses on the development and use of algorithms called large language models (LLMs). LLMs' ability to understand and communicate in human languages is dependent on the neural network that determines the way it processes information. Prior to 2017, AI relied on recurrent neural networks (RNNs), which process data sequentially. However, Transformer, invented by Google employees in 2017 [2], introduced an attention mechanism, which can process data in context and identify "long-distance dependencies between words [3]." Originally designed for translation purposes, Transformer changed the way that AI models intake and analyze information, particularly languages. Since 2017, this attention mechanism has revolutionized the way that AI functions, creating smarter technologies that better understand language and context. This led to the creation of LLMs, which have the capability to process text-based data more accurately and, most importantly, almost instantaneously. Seven years later, Transformer is considered "the best neural network…at present" and is the foundation for the most powerful language AI tools available today [4].

The boom in AI's capabilities has grown its user base exponentially. In particular, large language models in the form of "chatbots" have become widely popular across industries and demographics. In the first two months since its release in November 2022, OpenAI's ChatGPT, the most popular AI chatbot surpassed 100 million users worldwide; as of May 2023, over half of Americans are familiar with the concept of AI chatbots [5]. This popularity is changing the way that information is created and shared, especially among young people and more highly educated people. According to Pew Research Center, the groups most likely to know about and use these chatbots are adults ages 18-29, and likelihood of use increases with education level [5]. This poses both a unique challenge – and opportunity – for students, researchers, educators, and higher education in general.

The Challenge of AI in Higher Education

In higher education, students are expected to learn how to conduct research in their chosen field and communicate it effectively. However, students are increasingly preferring AI chatbots to perform essential parts of the research process, from information seeking to data

analysis to even writing research papers. A 2023 study indicates that 49% of higher education students have adopted language AI tools to write assignments and answer homework questions [6]. This indicates that students are automating essential parts of the research and learning processes, which could, potentially, impact their readiness for the workforce after graduation – namely, graduates' diminished ability to produce work independently and honestly. Even more concerning is the fact that most people can correctly recognize if written content was generated by AI only about 50% of the time [7]. So not only are students largely unable to recognize whether written content found online is AI-generated or not, but instructors also are not able to recognize when students are relying on AI to complete assignments. This is one of the motivations for this paper, in that the authors believe that users of AI should be informed of how these tools work, to be attentive to the outputs that these tools generate, and to be conscious of the impact these tools have on their own ability to learn and innovate.

The Opportunity for AI in Higher Education

The unstoppable use of AI tools by students has prompted institutions of higher education to assess the impact of this emerging technology within their academic settings. While universities have begun to address this trend through their academic integrity and ethics policies, students will continue to utilize AI regardless of rules and regulations that support or forbid use of AI. Educators must equip themselves and their students with information literacy and critical thinking skills, which will help ensure that students utilize AI ethically and responsibly. Focusing on effective use, rather than forbidding use entirely, will better prepare students for success academically and professionally. As educators, the authors of this paper use this sentiment as the basis for equipping first-year engineering students early on with AI literacy, as it is an important part of their education.

Theoretical Foundation: AI Literacy

AI literacy was a term first coined in 2015 by Yoko Konishi as the ability to recognize the advantages and limitations of AI and the use of these new technologies with caution [8]. In the spirit of this definition, many educators and professionals have explored the concept of AI literacy with a relatively critical attitude. In 2020, educators at the Georgia Institute of Technology proposed a new definition that, not only promotes critical evaluation of AI tools, but also encourages the use of AI in communication and collaboration in all aspects of life [9]. This definition embodies the reality that use of AI will continue to grow and become an integral part of everyday life, and thus, it places the responsibility on the user to be a conscious consumer of the technology.

AI Literacy Implementation Highlights

To tackle the use of AI at our university head-on, a teaching team comprised of a first-year engineering instructor and a research-and-instruction librarian sought to explore how AI literacy can be conscientiously, responsibly, and practically integrated into the first-year engineering curriculum. The teaching team designed an instructional module with two goals in mind: first, to train students on how to use an AI large language model generative chatbot, and second, to train the students on AI Literacy so they can analyze and interpret the synthetically generated outputs.

The course "Introduction to the Engineering Experience" is a required course offered every Fall semester to all first-year engineering students at our university. The course is grounded on the approach of Raymond Landis, who coined the term World Class Engineering Student (WCES) [10]. The approach focuses on development of soft skills including collaboration, reflection, peer review, and time management; skills which are increasingly recognized as an important part of student development and success in engineering education, and essential in the development of a WCES [11]. In the Fall of 2023 semester, the AI literacy module was added and delivered, with the belief that AI is an essential component of becoming a WCES.

AI Literacy Module Design

The AI Literacy module was designed collaboratively by the teaching team, using the American Association of Colleges & Universities (AAC&U) Valid Assessment of Learning in Undergraduate Education (VALUE) Rubric for Information Literacy [12]. Specifically, this rubric spans three dimensions: Accessing the Needed Information, Evaluating Information and its Sources Critically, and Accessing and Using Information Ethically and Legally. The learning outcomes for the AI Literacy module were as follows:

- *Students will be able to understand how AI functions in order to analyze the strengths and weaknesses of the technology.*
- *Students will be able to discuss the use of AI in engineering in order to formulate a position on where AI can be used ethically in their field.*

The lesson plans for each of the two sessions were designed in collaboration between the engineering instructor and reference and instruction librarian. The effectiveness of the AI literacy module was evaluated in two ways: quantitatively and qualitatively, as will be discussed.

AI Literacy Lesson Delivery and Data Collection

The AI literacy module was delivered to 128 students in two sessions of the Introduction to Engineering course in the middle of the Fall semester of 2023. The first session was delivered by the engineering instructor and the second by the reference-and-instruction librarian. Due to the number of students in each session, the lessons were delivered in a lecture hall, with active learning components implemented as instructors were able to.

In the first session, students learned why it is important to think critically about information as researchers. The instructor introduced the CRAAP test to evaluate information. The CRAAP test was designed by Sarah Blakeslee in 2004 to evaluate text-based information, using the criteria of Credibility, Reliability, Authority, Accuracy, and Purpose (hence the acronym) [13]. Students were asked to evaluate their choice of one of two sample articles – one from a peer-reviewed journal and one from a popular magazine – using the CRAAP test. This activity allowed them to get comfortable with evaluating information and asking critical questions of the information they encounter. The instructor then proposed that students could apply the CRAAP test framework to evaluating technologies. Students were encouraged to confirm that an AI tool is as reliable as any other type of resource used in their research. They were asked to consider the following questions ahead of the second session:

- Where does an AI tool get its information?
- How is an AI tool programmed to function?

Next, students were asked to create their own ChatGPT account and use it to experience how generative large language model AI (LLM AI) systems work. In small groups and as a whole class, students discussed how to create effective prompts, and how ChatGPT responds to these prompts.

In the second session, students were formally introduced to how ChatGPT processes information and constructs its outputs. Students were taught how large language models tokenize language, rather than having an innate knowledge of how language works. The reference and instruction librarian then presented some of the limitations of AI that students should consider. These included issues with unsupervised learning – meaning that ChatGPT determines rules and relationships on its own – as well as issues of bias and misinformation from what the AI tool is "fed." In addition, ChatGPT is not trained on data in real-time, meaning that it uses information that may be outdated [14]. Next, the reference and instruction librarian asked students to compare two writing samples, and vote on which was AI-generated (shown later). This was a pre-test to gauge students' ability prior to further instruction. Then, the librarian presented the AI Literacy criteria to evaluate whether content was generated by LLM AI. These criteria were developed by Charlie Heyser [13] which consider the following aspects of written text:

- Writing Style
- Context
- Creativity
- Grammar & Syntax
- Logical Coherence

The librarian walked students through how to apply these criteria to a writing sample that was generated by ChatGPT. Students were then asked to work with a partner on a new set of writing samples and make a more informed decision on which was AI-generated. Each pair of students was asked to agree on a decision before voting. Finally, the activity concluded with a class discussion of the limitations of AI bots, and the importance of thinking critically about AI-generated content. Students were asked to discuss the following questions:

- Based on your experience with creating ChatGPT prompts earlier this week, how can you write prompts in ChatGPT that will be useful to you?
- Can you think of any ways that you could use ChatGPT – or other tools – responsibly as an engineer?

These discussions focused heavily on how to create specific, limited prompts for ChatGPT, particularly creating lists of related concepts (for example, listing types of engineering or creating an outline structure for an essay). Students acknowledged the challenges of using ChatGPT more broadly and emphasized its usefulness as a tool for topic development and possibly reviewing, but not for research or writing.

Samples of the Activity

At the start of the second part of the activity, students were shown side-by-side samples of narratives produced by humans and by the AI bot, and were asked to identify which one was which through an online poll. This first poll generated the baseline pre-activity data. Figure 1. shows a sample of the narratives shown to students. Students had to pick whether A or B was generated by AI.

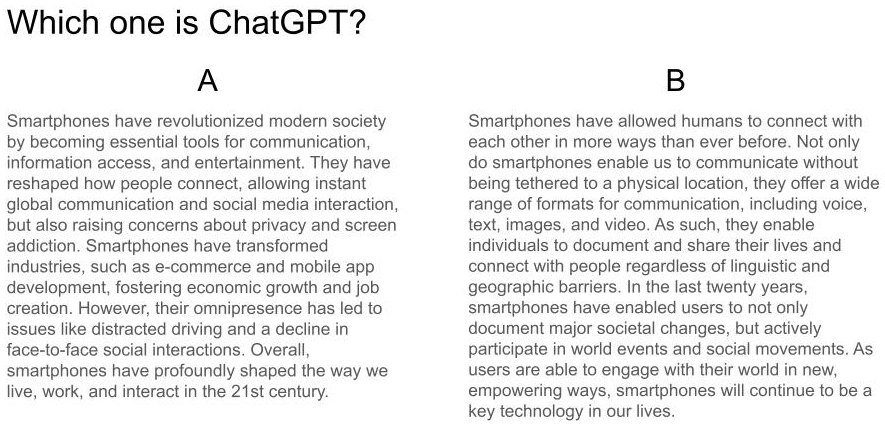

Figure 1: Two narratives presented to students side-by-side. A was generated by a large language model AI, and B was written by the reference-and-instruction librarian.

After this pre-test, students were coached on how to identify AI generated text using the provided criteria. Next, prompted by the librarian, students tested their new skillset by applying the criteria to a writing sample as a class (Figure 2).

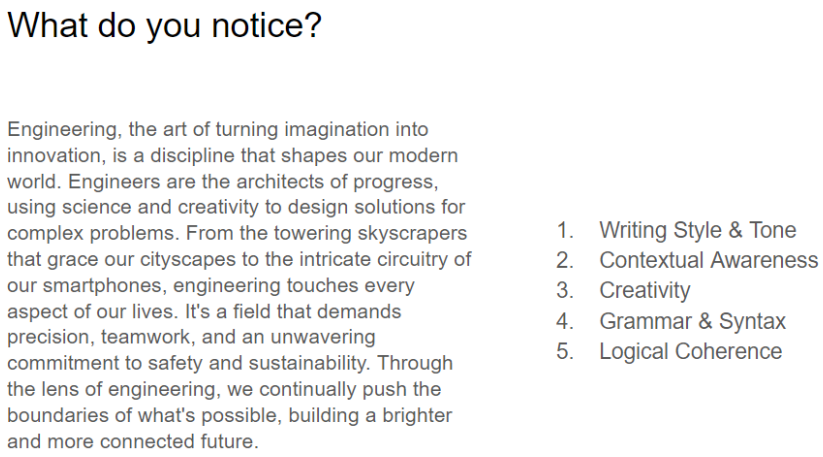

Figure 2: A ChatGPT-generated narrative was presented to students, and the librarian led the class in applying the criteria to this narrative.

At the end of the activity, after students were coached on how to identify AI generated text using the provided AI Literacy rubric, students were once again shown side-by-side samples of narratives (Figure 3) produced by humans and by the AI bot, and were asked to work with a partner to identify which one was which through an online poll. This second poll generated the post-activity data.

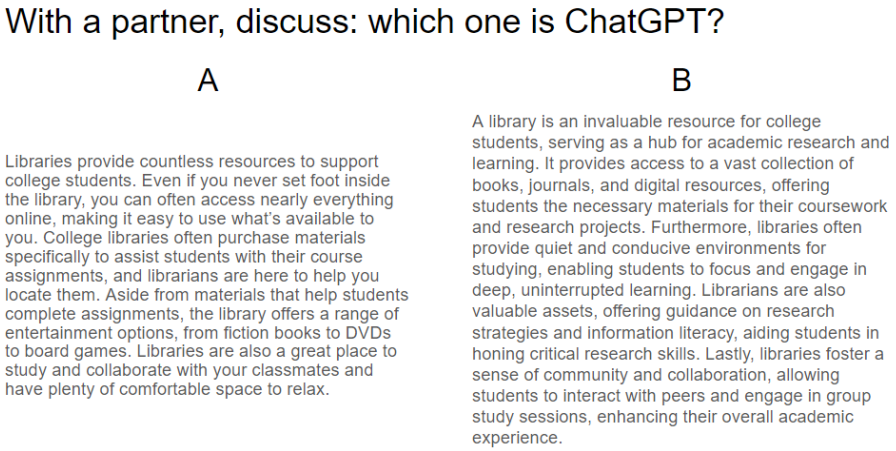

Figure 3: Two narratives presented to students side-by-side. A was written by the reference-and-instruction librarian, and B was generated by a large language model AI.

Quantitative Data Analysis: Polling

The quantitative analysis was conducted from the pre and post activity surveys and the results are summarized in Figure 4. The figure compares the student's ability to identify the AI generated text before the activity, and after the instructional activity. The two bars on the left show that, prior to instruction, students were able to identify the AI generated text about half the time (52% vs 48%) which is consistent with research on identifying AI generated text [7].

The two bars to the right show that after instruction, students were able to identify the AI generated text correctly 70% of the time. This indicates that the instruction improved students' ability to identify AI generated text considerably, since the accuracy in detecting the AI generated text increased from 52% to 70%.

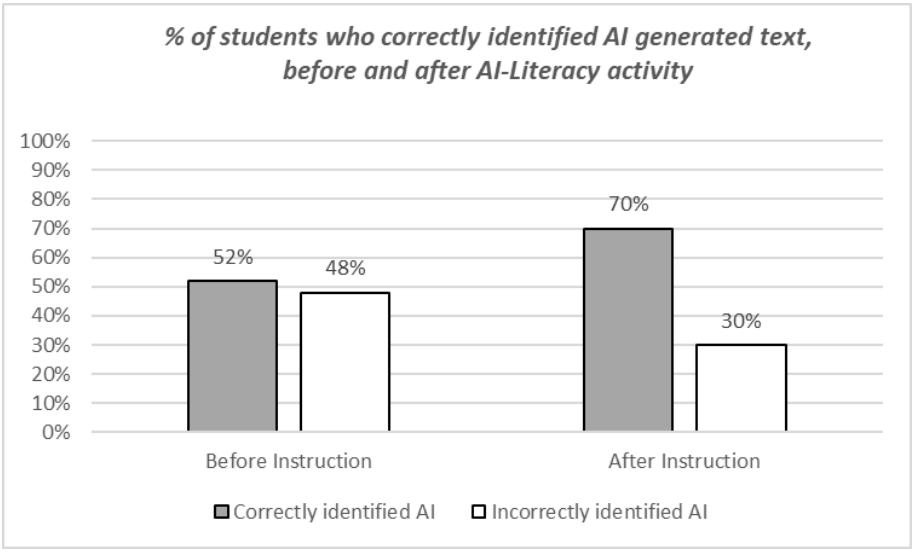

Figure 4: The bars indicate percentage of students who were able to identify AI generated text accurately, before the activity (bars on the left), and after the activity (bars on the right). Sample size was 50 respondents.

Qualitative Data Collection

At the end of the semester, after students had the opportunity to apply and explore the AI tools more broadly in their studies, students were asked to reflect on three statements on AI as part of their end-of-semester digital e-portfolio for the course:

> *As future engineers, it is vital that you are able to address the growing use of artificial intelligence in your field. You will likely be asked questions about artificial intelligence in co-op and job interviews, because employers will want to know your perspective on its ethics and use. For your portfolio, write a brief statement about AI on the following:*
> 1. *One sentence explaining your personal philosophy on using artificial intelligence in engineering.*
> 2. *One sentence explaining how your values on academic integrity and ethics relate to the growing artificial intelligence industry.*
> 3. *One sentence about an AI tool relevant to your chosen field of engineering (not ChatGPT), and how you would use it effectively in your work.*

These statements on AI were submitted by students through the learning management system. Student's responses varied in format, from a numbered list corresponding with parts of the prompt to a narrative paragraph. Responses in paragraph format were parsed into separate parts according to the prompt, but not edited, for thematic analysis.

Thematic Analysis Methodology

Thematic analysis was implemented to evaluate the effectiveness of the module. Thematic analysis provides a way to systematically analyze qualitative data and is performed following a five-step process: data acclimation and familiarity, line-by-line coding, initial theme identification, further theme expression, and review of themes based on the complete data set [15] [16]. The authors utilized Dovetail, a software package that performs thematic analysis from textual data. The most represented themes identified were the following four:

> ***Theme 1****: AI is an incredible tool with applications in every engineering industry. It should be used for generalization and to save time, but not for design, calculations, or product development.*
>
> ***Theme 2****: AI in engineering widens human capabilities and tackles complex problems efficiently. However, over-reliance on AI reduces exploration and makes the engineer's role redundant.*
>
> ***Theme 3****: AI provides ideas, outlines, and images. However, its abilities raise ethical concerns about intellectual property and proper attribution.*
>
> ***Theme 4****: As an engineering tool, AI is created by and should be improved by engineers. It is not yet advanced or trustworthy enough to perform engineering capabilities independently.*

Discussion

The themes identified not only speak to the direct goals the lesson plan, but also to the fact that the students themselves have begun to internalize their awareness of the role of AI in

their educational experience. Each of the four themes identified relates to curricular components of the AI literacy lesson module and it is encouraging that students recognized them and reported them in their responses.

These themes also indicate that students believe there is inherent value in developing AI literacy skills. Students admit that there are strengths to using AI, and are able to articulate the advantages and disadvantages of these tools in the context of their studies. Thinking critically about technology in this way is a crucial part of being an engineer. Further, by recognizing the limitations of current technologies, students realize that the role of humans is still essential when utilizing AI tools.

Both the quantitative and qualitative results presented above indicate that the AI literacy instructional module has been effective in achieving its goals. Mainly thanks to AI literacy instruction, students better understood how AI operates and were able to critically evaluate AI technologies' strengths and weaknesses. Applying AI literacy to discern authorship of written text, enabled them to practice these skills and more fully grasp the ways in which language AI generates content, with improved success.

While this module was designed for a first-year engineering course, the authors plan to continue applying this lesson plan in future sessions to collect more data and further validate the AI literacy approach proposed here. If possible, the authors would like to provide this instruction to smaller class sizes, to facilitate more discussion and active learning opportunities. In addition, future extensions of this work may include a scaffolded AI literacy curriculum built into the existing engineering program, implementing AI literacy in more advanced courses using various types of AI technologies. This would require expanded collaboration with more faculty members, as well as deeper research into the types of AI tools, such as coding assistants and simulators, that engineers can apply to their work.

Conclusion

AI is now an integral part of modern education (and life). As AI LLMs continue to evolve with the goal of become more realistic and human like, students and professionals alike will be required to think critically about the origin (and creator) of any information they discover. Educating users on how to recognize AI-generated content, to become ethical and responsible consumers of AI, will ensure that they are aware of the benefits and risks of using such tools.

The approach presented here was an initial attempt at including an AI-Literacy module in the engineering course to allow students to gain awareness of the role and importance of AI in their studies. In doing so, these students will be more prepared for their future, where they will inevitably be required to have an informed perspective on AI, in their education, jobs, and in their daily lives. AI technologies and their applications are rapidly evolving, and becoming more human-like. AI literacy is therefore vital for preparing students for future advancements in the technology.

IRB Statement on Data Usage

The data utilized in this study was anonymized and aggregated and was deemed as "exempt" by our university's IRB committee.

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