Artificial Intelligence in an Online Engineering Economy Class

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Abstract

Artificial Intelligence (AI) tools are abundantly available to anyone using a device with Internet connection. While the improper use of AI in higher education can mean cheating during summative assessments, the focus of this paper is to present evidence that the student's curiosity to investigate AI tools can be leveraged in formative assessments. Encouragement from the faculty can turn the AI tools into learning enhancers while the integrity of the major course assessments can be maintained by proctoring.

Introduction

In the presence of AI, people can interact and receive real-time feedback by creating and using effective prompts [1]. Students are increasingly aware of AI tools and some use it guiltlessly on homework assignments [2]. However, an engineering professor is still responsible for offering authentic education so students can identify, formulate, and solve complex engineering problems [3]. AI tools can have a positive or negative influence on education and their use in the engineering economy class is investigated.

The Engineering Economy class is offered in the mechanical engineering program at The University of Texas at Dallas in the asynchronous online modality. The design of this course is based on the backward design method [4], similarly to other courses described in our previous publications [5,6].

The course is an elective for mechanical engineering students. Forty-seven (47) students took the class in the Spring of 2024 and forty (40) in the Fall of 2024. The Engineering Economy course has four learning outcomes, where the following is expected from the students upon successful completion of the course.

1) Be able to identify, formulate, and solve time value of money problems using mathematical equations, computer software, and tables.
2) Be able to influence engineering design decisions based on cost estimation and market pricing.
3) Be able to communicate economic decisions effectively using profit margin calculations, breakeven analyses, payback period analyses, and risk assessments.
4) Be able to explain the ethical responsibility of managing money in engineering projects.

The course has minor and major assessments, each worth 50% of the total grade. The minor assessments are in the form of low-stake quizzes and homework assignments, each worth 1% to 3% of the grade in the class. The quizzes cover the lecture materials, where two attempts are allowed. The homework assignments require hand calculations and Excel work. The students are asked to upload their work to the learning management system for grading. These are intended as formative assessments to give the students some practice problems and feedback on their work.

The major summative assessments are Exam 1 and Exam 2 near the middle and end of the semester, respectively. These exams are offered online in the form of multiple-choice questions similarly to the Fundamentals of Engineering exam [7]. However, to encourage notetaking while watching online lectures and other course content, the exams are offered with open notes. Furthermore, to encourage the students to study the textbook [8], the exams are offered "open book" as well. An average of three (3) minutes per question is allowed. This time constraint makes it essential for the students to study and write notes throughout the semester to successfully solve problems during the exam. Furthermore, using help from others (humans, search engines, or AI) is not allowed on the exams. Proctoring by Honorlock [9] is enabled where the screen activity is recorded, and the student's webcam is activated throughout the exam.

The AI Assignment

The AI assignment is shown in Fig. 1 based on a problem in the textbook [8]. The students are asked to solve the problem manually first (using pencil and paper in addition to Excel), according to what they learned in the lecture about the incremental ROR analysis. Specifically, they are expected to place four mutually exclusive options in the order of decreasing first cost (Table 1) and calculate the i* for each investment option. For all options with i* > MARR, an incremental Δi^* is calculated between each two remaining options to, finally, select the best option.

Table 1, The four mutually exclusive options

	A	B	C	D
First Cost = P	-30000	-36000	-41000	-53000
Annual Net Income = A	4000	5000	8000	10500
Salvage Value = F	1000	2000	500	-2000
n	8	8	8	8

The rate of return for each option can be calculated using the interest rate tables or using Excel. The resulting values of i* are 2.1%, 3.4%, 11.3%, and 11.1%. Since MARR is given in the problem statement as 11%, options A and B are eliminated because their i* is less than MARR. Since all options have the same duration, n = 8 years, Option C has the highest value of i*, which can be expected to declare Option C is the best. However, to complete the incremental ROR process taught in the course, a comparison between Options C and D can still be done by subtracting D – C, as shown in Table 2 and calculating on the increment a rate of 10.4%, which is less than MARR. This conclusively identifies Option C as the best among the four mutually exclusive options.

Table 2, Comparing Option C to Option D

	D - C
First Cost = P	-12000
Annual Net Income = A	2500
Salvage Value = F	-2500
n	8

INSTRUCTIONS

This is a BONUS homework (worth 1 point as a BONUS grade).

Use AI to help you calculate the rate of return for each of the four following mutually exclusive options and decide which is the best option to use if MARR = 11%?

- Alternate A: First cost is $-30,000, Salvage Value = 1000, Annual net income = +4000, n = 8 years
- Alternate B: First cost is $-36,000, Salvage Value = 2000, Annual net income = +5000, n = 8 years
- Alternate C: First cost is $-41,000, Salvage Value = 500, Annual net income = +8000, n = 8 years
- Alternate D: First cost is $-53,000, Salvage Value = -2000, Annual net income = +10500, n = 8 years

Please answer in 3 steps to get the bonus credit:

1. Manual Solution: Insert your manual solution here: calculate i* for each option and reject the options with i* < MARR. Then, compare the remaining options and select the best option. This is done manually using your pencil and paper + Excel. You can take a picture of your solution and paste the picture in your submittal file or you can type the equations used.
2. Use GenAI (e.g., https://openai.com/chatgpt/ or https://copilot.microsoft.com/ or https://gemini.google.com/app or other): This part is done by creating prompts and interacting with AI. Enter your prompts and the AI response.
3. Conclusion: Explain if you can get AI to solve the problem or guide you to solve the problem. Provide your related feedback and your recommendations.

See the example in the attached file to help you do this assignment. A smaller problem is included in the attached file as an example.

Example.pdf

SUBMISSION

Create Submission

Upload Files

Add Comments

Fig. 1, Bonus assignment statement

Next, the students are asked to use GenAI to analyze the problem. An example is provided to help in writing effective prompts. In this example, the first prompt is: “I am a student taking a college engineering economy class. Can you help me to solve a problem please?” Here, the persona is defined by “I am a student,” the context is defined by “taking a college engineering economy class,” the objective is defined by “can you help me to solve a problem?” Furthermore, the example explains that guardrails can be added and ending the question with “please” can give a nice touch in treating AI as a friend instead of simply typing commands.

The next prompt in the provided example is the actual question: “What is the rate of return for this investment: First cost is $-30,000, Salvage Value = 1000, Annual net income = +4000, n = 8 years?” This example is Option A in the actual homework assignment shown in Fig. 1.

When these prompts are entered in ChatGPT at the time of creating the assignment (September 2024), the response includes a cash flow summary for years 0 to 8 and ChatGPT responds: “In Excel: =IRR(A1:A9) where A1 to A9 contains the cash flows.”

The third prompt in the provided example is “What is the actual value?” This should yield i* = 2.1%. However, ChatGPT responds: “you should find that the IRR (rate of return) is approximately 9.65%.” This response by AI gives the professor an opportunity to explain in the example the concepts of hallucinations and misalignment, where AI produces content that is untrue or factually inaccurate or when AI is prompted for a specific output but produces an unexpected or undesired result.

The final prompt in the example asks the AI: “Can you give me values so I can copy-paste them in excel?” In response, the values are provided neatly with no text, so they can be copied and pasted into Excel. A statement is also given by AI. “Just paste these values into cells A1 to A9 in Excel, and then you can use the formula =IRR(A1:A9) to calculate the internal rate of return. Let me know if you need any more help!” When the values are pasted in Excel and the function is executed, the correct value of 2.1% is obtained.

The homework assignments request a review of the example before solving the complete homework problem. If simply copied and pasted into ChatGPT [9], Copilot [10], or Gemini [11], AI gives some of the methodology to solve the homework problem but does not give the correct answers as of the date of writing this paper. The AI gives different solution methods as well.

Results

The performance of the students on this assignment places them into one of four categories: below expectations, progressing to criteria, meets expectations, and exceeds expectations. Students who fully relied on AI to solve the Engineering Economy problem are placed in a **below** expectations category with the assumption that they do not know how to solve the problem on their own. One student admitted copying the response by AI and simply reiterated the procedure given by AI. The correct i* values are given by the AI in this particular case, and Option C is selected by AI since it has the highest i*. The incremental ROR procedure taught in the course is not applied. The conclusion provided by this student indicates that the AI yields a clear solution and selection of the best option.

Other students demonstrated that they knew some steps in solving the problem and they were confused or intrigued by the solution provided by AI. For example, a student never calculated the i* values for the four options and started by immediately calculating Δi* between each two options by hand. An error in the calculations incorrectly led to a conclusion that Option D is best. This student is **progressing** to criteria since some correct steps were taken despite the error and even though other steps were missed. ChatGPT gave this student incorrect i* values of 10.82, 10.84, 16.43, and 15.9% for options A, B, C, and D, respectively. AI informed the student that Option C is the best option, which is correct even though all the i* values are incorrect. The student concluded that AI could give helpful steps to solve the problem but can give incorrect answers.

Most of the students solved the problem correctly by hand or using Excel but did not make full use of the AI tools. For example, a student calculated the i* values correctly for the four given options and proceeded to calculate Δi* between Options C and D correctly. The conclusion that Option C is the best was reached. This student **meets** expectations for the Engineering Economy class. When using the AI tool, ChatGPT calculated the present value based on MARR for all the options and concluded that Option C is the best option since it has the highest net present value. The student acknowledged that AI used a completely different method to solve the problem but selected the correct option.

Finally, some students **exceeded** expectations by demonstrating an understanding of the course content. They solved part 1 of the homework according to the method taught in the course and they were able to guide AI to arrive at the correct methodology and calculations. After interacting with AI on this problem, some students insisted with persistent prompts to guide AI to solve the problem using the steps they learned in the course. One student wrote that ChatGPT can generate Python code, compile it, and run it to give the correct answer. Another student wrote that AI could solve equations iteratively using numerical methods like Newton-Raphson to find the IRR for each option.

The conclusions provided by most students indicate that AI tools give answers quickly, but the answers may not be accurate. The user should understand the materials and determine if the given answers are incorrect. There is consensus among the provided conclusions that learning the materials is more effective than getting questions answered by AI. However, AI remains an effective, powerful, and helpful tool.

Engaging the students with AI is an attractive experience to engage students in learning the course materials. A definite up-tick in the number of emails and questions occurred following this extra-credit assignment even though only a quarter of the students submitted the bonus assignment. AI is intriguing and students can use it in a positive way following an investment and a reward from the faculty.

It is also our experience that AI is not attractive enough for students to engage without a reward. A post by the professor on the discussion board, shown in Fig. 2, remains unanswered and eventually forgotten.

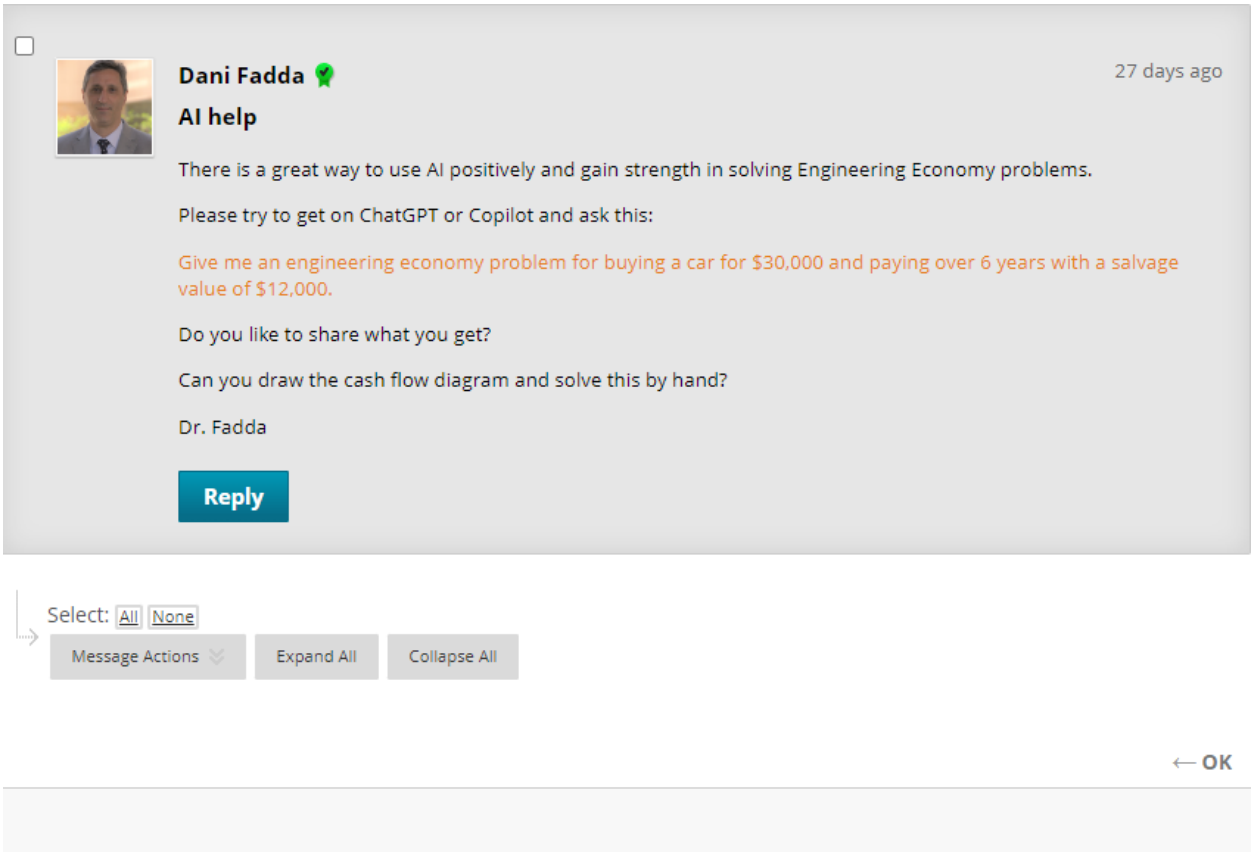

Fig. 2, Discussion board post asking students to voluntarily use ChatGPT or Copilot Posted in Week 3 of the semester with no response from any student

Conclusions

Making students aware of the benefits and drawbacks of AI is considered a better alternative than simply locking AI out of the class. The use of AI in a low-stake formative assessment can get students engaged with the course materials. Regardless of the student's performance level, the use of AI can cause students to ask questions and explore the AI tool's capabilities in relation to their course materials. Specifically, engineering the AI prompts resembles teaching and leading the AI tool to achieve the desired solution method and answer. Since teaching is one great way to learn, this process is considered a valuable learning experience. Conclusions provided by the students indicate that this assignment helped them with the engineering economy concepts and with using AI responsibly.

This may not be the case for the summative assessments which are offered in a multiple-choice format similarly to the Fundamentals of Engineering exam. Students performing below expectations in the course can rely on AI to do their work and they can gain an improper advantage when AI gives correct answers. Therefore, offering proctored midterm and final exams with no access to AI is recommended for major assessments.

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