

Student Use of Artificial Intelligence to Write Technical Engineering Papers – Cheating or a Tool to Augment Learning

Dr. Ronald P. Uhlig, National University

From 2010-2014, Dr. Ronald P. Uhlig was Dean, School of Business and Management, National University, La Jolla, CA. He returned to the engineering faculty in 2014 and is currently Chair, Department of Engineering, School of Technology and Engineering. During 2005-2010 he served in multiple positions including Chair of the Department of Computer Science and Information Systems, and Academic Program Director for the Master of Science in Wireless Communications; as well as Principal Investigator for two HP Technology for Teaching grants. From 2000-2005, he was President/CEO, SegWave, Inc., an educational technology systems company he founded.

Previous positions include Vice President for Russia and Eastern Europe, Qualcomm Inc., 1995-99, with offices in San Diego and Moscow, Russia and multiple positions with Northern Telecom and Bell-Northern Research in Ottawa, Canada and Richardson, TX during 1978-1995, including Director, Intelligent Network Solutions and Director, Asia/Pacific Strategic Marketing. He is one of several "Fathers of email", based on work he did with the US Army and DARPA in the 1970s and several international committees he chaired during 1979-91. Those committees took him to nearly 100 countries globally. He had nationwide responsibility for US Army Materiel Command Scientific and Engineering computing, 1969-78, pioneering many applications in what has become today's Internet, and he served as a US Army Officer in the Office of the Chief of Staff, in the Pentagon, 1966-1968.

He holds a B.Sc. in Physics from the Massachusetts Institute of Technology, and a Ph.D. in Physics from the University of Maryland. He is the recipient of a Gold Medal from the International Telecommunications Academy for sustained contributions to telecommunications; the Silver Core from the International Federation for Information Processing; and the Founders Award from the International Council for Computer Communications. He has served as a member of the Steering Committee for Project Inkwell.

Dr. Shatha Jawad Jawad, National University

Dr. Shatha Jawad has more than 22 years of experience in teaching and more than three years as a software engineer. She had UNESCO Fellowship in the field of Information and Communication Technologies, in 2002. Her Ph.D. is in computer engineering. She is a member of the Institute for Learning-enabled Optimization at Scale (TILOS) which has an NSF grant that began on November 1, 2021, for five years. TILOS is a National Science Foundation-funded Artificial Intelligence (AI) Research Institute led by the University of California-San Diego and includes faculty from the Massachusetts Institute of Technology, the University of Pennsylvania, the University of Texas at Austin, Yale University, and the National University.

Dr. Bhaskar Sinha, National University

Dr. Bhaskar Sinha is a Professor in the School of Engineering and Computing at National University in San Diego, California.

Dr. Pradip Peter Dey

Dr. Pradip Peter Dey has more than 20 years of experience in Computer Science research and education. His university teaching and professional experience emphasizes mathematical modeling, information extraction, syntax and semantics of natural language, w

Dr. Mohammad N. Amin, National University

Mohammad Amin received his Ph.D. and M.S. degrees in Electrical Engineering & Computer Engineering, and M.S. degree in Solid State Physics from Marquette University, Milwaukee, Wisconsin. He also received M.Sc. and B.Sc. degrees in Physics from Dacca University. Currently, he is working as a Professor of Engineering at the National University, San Diego, California. He received the President Disguised

Teaching Award in 2020 and two times President Professoriate Awards. He published and presented 100+ technical papers in the peer reviewed journal and conference proceedings. He edited nine conference proceedings, chaired nine conferences including 2009 ASEE/PSW and 2015 ASEE/PSW and three US Patents.

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Abstract

Considerable concern has emerged over the potential use of AI tools by students for completing assignments in their classes. Reactions in academia have been mixed, with some describing such use of AI tools as “cheating” while others compare it to the use of calculators and see it as the impetus for enabling deeper learning by students. To analyze some of these issues, the recently released AI tool ChatGPT was used to respond to actual Discussion Board questions in our online cybersecurity classes. ChatGPT was also asked to write a Python program to develop a backpropagation Neural Network for XOR. The results were excellent, both for answering the Discussion Board Questions and for writing code. Four findings emerged from this effort: 1) ChatGPT does an exceptional job of answering questions and generating code, 2) it is not clear how student submissions generated with AI should be graded, 3) along with the AI tools themselves, tools have been developed that can detect whether AI was used to generate a student submission but with a high rate of false positives, and 4) despite these three findings, students could and should be encouraged to collaborate with AI tools, similar to the way they would collaborate with other students. These results led to four conclusions: 1) ethically, the use of tools such as ChatGPT without acknowledging that they have been used *is* cheating, 2) it will be impossible to stop students from using tools like ChatGPT, but unacknowledged use can be detected, albeit with a very high percentage of false positives, 3) use of AI tools should be encouraged rather than discouraged, and 4) higher education should focus on new methods and mechanisms for assessing student learning that take advantage of the AI tools.

Introduction

Artificial Intelligence (AI) has made enormous strides during the past few years. It has become possible for AI to provide answers to essay questions on exams, generate good discussion board posts in online courses, write code in programming classes, and even whole student papers based on a few simple prompts. Considerable concern has been expressed over the emerging use of AI tools by students for completing assignments in their classes. Reactions by those in academia have been mixed, with some describing such use of AI tools as “cheating” while others compare it to the use of calculators in the classrooms of twenty years ago and see it as the impetus for enabling deeper learning by students.

Susan Agostino wrote “Humans have long relied on writing assistance, powered by artificial intelligence to check spelling and grammar, predict text, translate, or transcribe. Now anyone with an internet connection can access an AI tool such as OpenAI or Moonbeam, give it a prompt and receive, in seconds, an essay written in humanlike prose.” She goes on to note that, “As math professors once had to adjust their math teaching in the presence of calculators, writing instructors may need to adjust their teaching in the presence of AI tools [1]”.

In his article, “The College Essay is Dead,” Stephen Marche quotes a tweet by Kevin Bryan, an associate professor at the University of Toronto, “You can no longer give take-home exams/homework ... Even on specific questions that involve combining knowledge across

domains, OpenAI chat is frankly better than the average MBA student at this point. It is frankly amazing [2].” In the same article Marche discusses research into AI text generation by Mike Sharples, a professor in the U.K. Marche comments, “Sharples’ intent was to urge educators to ‘rethink teaching and assessment’ in light of the technology, which he said, ‘could become a gift for student cheats, or a powerful teaching assistant, or a tool for creativity.’ ”

Susan Agostino quoted Robert Cummings, “AI can impact every stage of the writing process – from invention to research, drafting, proofreading and documentation.” She went on to quote Fyfe who said, “Think about it as a partner, that we humans and AI computers are not doing things the same way and aren’t good at the same things, either. Each has unique specializations. What are the kind of partnerships we can imagine [3]?”

Beth McMurtrie commented, “It is critical, [scholars] say, to begin conversations with students and colleagues about how to shape and harness ... AI tools as an aide, rather than a substitute, for learning,” and she noted “digital literacy has to include an understanding of how AI works [4].”

In a blog post, Mike Sharples describes these tools as a “transformer” and then proposes several ways in which AI can be harnessed for learning:

“First, Transformers can quickly show students different ways to express ideas and structure assignments. “

“Second, AI Transformers can be creativity tools.”

“Third, teachers can explore the ethics and limits of AI. How does it feel to interact with an expert wordsmith that has no morals and no experience of the world? Does a “deep neural network” have a mind, or is it just a big data processor?”

“Finally,” he asks, “as educators, if we are setting students assignments that can be answered by AI Transformers, are we really helping students learn? ... If Transformer AI systems have a lasting influence on education, maybe that will come from educators and policy makers having to rethink how to assess students, away from setting assignments that machines can answer, towards assessment for learning [5]”.

Analysis

The OpenAI system ChatGPT [6] was used to analyze potential responses to some student assignments in existing courses. Bernard Marr describes ChatGPT as “an AI-based chatbot system that uses Natural Language Processing (NLP) to generate conversations.” He went on to note that “ChatGPT enables users to ask questions or tell a story, and the bot will respond with relevant, natural-sounding answers and topics. The interface is designed to simulate a human conversation, creating natural engagement with the bot. Based on GPT-3.5, a language model trained to produce text, ChatGPT is optimized for conversational dialogue using Reinforcement Learning with Human Feedback (RLHF). Responses from ChatGPT sound quite human-like because they were trained on vast amounts of data written by people [7].” A recent McKinsey

article noted that “estimates indicate that GPT-3 was trained on around 45 terabytes of text data. [8]”

ChatGPT is one example of the kind of AI power that has become available for free to students. ChatGPT is continually being updated with an enormous collection of data from many sources. In response to the question, “What dataset was used to train you?” ChatGPT responded that it was “trained on a dataset called ‘GPT-3’, which consists of a large amount of text data from a variety of sources such as books, articles, and websites. The dataset is constantly being updated with new text data as it becomes available.”

ChatGPT was used to generate responses to two different Discussion Board questions in one of our online cybersecurity courses. The authors are grateful to our colleague, Christopher Simpson, for the following Discussion Board questions along with responses to the questions generated by ChatGPT [9].

Discussion Board Question 1:

In today's computing world, the traditional definition of a corporate network no longer applies, due to the increased use of cloud computing services and mobile computing devices. In your own words, describe how Network Security Monitoring fits into this new paradigm and, with these other services and devices being used within a company, who should be responsible for securing and monitoring the network and devices beyond the corporate network boundary? Is your concept feasible? Is it already a reality for some organizations?

ChatGPT Answer:

“In today's computing world, the traditional definition of a corporate network has evolved due to the increased use of cloud computing services and mobile computing devices. Network security monitoring is an important aspect of securing and protecting a company's network and data, regardless of the devices and services being used.

In this new paradigm, the corporate network boundary is no longer limited to the physical devices and servers within a company's office. Instead, it encompasses all devices and services that are connected to and used by the company, including those in the cloud and those accessed via mobile devices. As a result, it is important for organizations to ensure that their network security monitoring systems are able to monitor and protect all of these different types of devices and services.

Who is responsible for securing and monitoring the network and devices beyond the corporate network boundary depends on the specific organization and its policies and procedures. In some cases, the responsibility may lie with the IT department or a dedicated security team. In other cases, the responsibility may be shared among different teams or departments, such as the IT department, the security team, and individual employees.

The concept of securing and monitoring all devices and services within a company's network boundary is feasible and is already a reality for many organizations. Many companies have implemented network security monitoring systems and procedures that are able to protect their

entire network, regardless of the devices and services being used. These systems and procedures may include firewalls, intrusion detection and prevention systems, and other security measures that are designed to protect against threats and vulnerabilities. Additionally, companies may also have policies and procedures in place to ensure that employees are aware of and follow best practices for secure computing, such as using strong passwords and avoiding risky websites and activities.”

Discussion Board Question 2:

Richard Bejtlich, in Chapter 9 of *The Practice of Network Security Monitoring*, describes a “Defensible Network Architecture.” He initially developed the concept in a 2008 blog post “Defensible Network Architecture 2.0” (<https://taosecurity.blogspot.com/2008/01/defensible-network-architecture-20.html>) Post your thoughts on the concept of defensible networks (you can do your own research) - do you think they are worth the effort? Does your organization have a defensible network (if permitted to discuss it)? You can also highlight any recent news articles related to defensible networks. How would you advocate defensible networks to your organization's leadership (if you do not already have one)?

ChatGPT Answer:

“The concept of a defensible network, as described by Richard Bejtlich, refers to a network architecture that is designed to be secure and resilient against threats and attacks. A defensible network is one that is carefully planned and structured, with layers of security controls and monitoring in place to detect and respond to potential threats.

I believe that defensible networks are worth the effort for organizations that are concerned about the security and integrity of their data and systems. A well-designed and implemented defensible network can help to prevent or mitigate the impact of cyber-attacks, which can be costly and disruptive to a business. In addition, a defensible network can provide peace of mind and confidence to employees, customers, and other stakeholders, as it demonstrates a commitment to security and risk management.

I am not able to discuss whether my organization has a defensible network, as I am a language model and do not have access to information about specific organizations.

If I were advocating for a defensible network to an organization's leadership, I would highlight the importance of network security and the potential consequences of not having adequate protections in place. I would also emphasize the value of a well-planned and structured network architecture, which can help to prevent or mitigate the impact of threats and attacks. In addition, I would outline the various components and features that can be included in a defensible network, such as firewalls, intrusion detection and prevention systems, and security information and event management systems. Finally, I would recommend conducting a risk assessment to identify any potential vulnerabilities or weaknesses in the current network and develop a plan to address these issues as part of the transition to a defensible network.”

The AI tool has generated a significant amount of information for students to review. One way of helping students learn would be to invite them to summarize, in bullet form, key new items they

have learned through use of the AI tool. Also note the part of the ChatGPT response that has been put in italics. The AI tool lets us know that it is a “language model” – not a human being.

Use of ChatGPT to Write Code:

Co-author Shatha Jawad used ChatGPT to attempt to write code in several different programming languages including C#, C++, Python, and Java. For simple programs, ChatGPT successfully generated the code along with comments and an explanation of the overall idea at the end. However, for more complex programs, ChatGPT would only start, but not complete, the code. For challenging programs, ChatGPT occasionally generated code without errors, but it was not always the best solution. This will be the subject of another paper on which the authors are currently working.

An example of the use of ChatGPT to write a simple code, instructed the AI to “Write a Python program to develop a backpropagation Neural Network for XOR.”

ChatGPT wrote the program without any errors. When the AI-generated code was executed, it worked as expected. ChatGPT did not just generate the code, it also generated excellent comments for each part of the code it generated. This was one of the most helpful things about the resulting code and could be extremely helpful to students who are just learning how to program.

It should also be noted that this question did not ask for written code for a specific problem. For the code to be useful, we first needed to design the Neural Network, such as the number of neurons per layer and the number of hidden layers; ChatGPT did all that. At the end of the program, ChatGPT wrote a paragraph explaining some important notes about the designed Neural Network. ChatGPT answered the question like a teacher explaining the answer in detail. The following is the summary that ChatGPT provided after writing the simple program:

“This program uses a 3-layer neural network with 2 input neurons, 3 hidden neurons, and 1 output neuron. It uses the sigmoid function as the activation function and trains the network using backpropagation with 10000 iterations. The XOR problem is a classic example of a problem that cannot be solved by a linear classifier, so a neural network with a non-linear activation function like sigmoid is needed to solve it.”

Findings

Four key findings emerged from the authors’ analysis:

1. Numerous, although not all, papers to date agree that the AI tools referenced can generate good papers, good code, and good answers. Experiments have been conducted to show that they can even pass a number of major exams, including a Wharton MBA exam, all three parts of the United States Medical Licensing Exam, and exams in four law school courses [10]. One of the most important findings of recent studies is that the AI tools are good in generating answers to traditional assignments used for fair assessment of learning, and these tools are likely to become better. The main question raised in this paper is extremely important for all stakeholders in modern education. However, instructors are already facing

challenges underlying the main question because the AI tools are already available to their students for completing assignments for grading. Depending on the course materials and contexts, instructors should be able to decide about the challenges posed by the use of AI tools. Grading is expected to be based on a fair assessment of learning. A reasonable instructor must decide whether to require students to cite the text generated by AI tools with appropriate citations and references as these practices are commonly required for grading assignments with standard references. If a student does not want to use AI tools for some reason, then the instructor may have to decide how to grade assignments completed with different options. In a given context, the instructor may be able to face the challenges if they are given freedom with appropriate responsibility.

2. A Key issue is “how should we grade?” to accurately reflect student learning.

When we asked the following question to Open AI’s ChatGPT it immediately generated the answer shown with the citation and references given below.

Question: “How can a teacher grade an assignment, which is completed by a student using ChatGPT?”

ChatGPT Answer: “ChatGPT is a chatbot that uses a variant of the GPT (Generative Pre-training Transformer) language model to generate text based on a given prompt. It is not designed to be used as a tool for completing assignments or for grading purposes.

If a student has used ChatGPT to complete an assignment, it would not be an accurate representation of the student's own understanding or knowledge of the subject matter. As a teacher, it would not be appropriate to grade the assignment based on the output of ChatGPT. Instead, the teacher should focus on evaluating the student's own understanding and skills related to the assignment.

If a student is found to have used ChatGPT or any other automated tool to complete an assignment, it may be considered academic dishonesty and could result in consequences such as a lower grade or even a failing grade for the assignment or course. It is important for students to understand the importance of completing assignments independently and honestly in order to demonstrate their own understanding and skills.”

Some instructors may choose to follow these suggestions made by ChatGPT; however, there is no “one size that fits all” solution for this problem. Stakeholders in modern education have to deal with the challenges posed by the AI tools in their context [5, 11]. Some instructors may choose to use an AI tool as a virtual teaching assistant [10]. We found that most stakeholders are honestly participating in well-balanced debates of issues in order to avoid harm to any stakeholder due to misinformation, disinformation, assumptions, perceptions, and lack of clarifications.

3. Along with the AI tools themselves, tools have been developed that can detect whether AI was used to generate a student submission. Unfortunately, current detectors generate a high rate of false positives - claiming that AI was used to generate a submission although it was not used.

As AI tools have evolved that generate good answers to student assignments, several tools have been developed for detecting whether or not something has been written with AI. Tools to detect plagiarism are already in widespread use in academia. Our university currently uses Turnitin for this purpose [12]. Students are typically advised that their writing assignments will be submitted to Turnitin and that Turnitin must show that less than some percentage of their assignment was copied from other sources or there may be a substantial deduction to their grade. A similar approach can be used to control inappropriate use of AI tools.

A Princeton University student made headlines recently with an application to detect essays written with ChatGPT [13], but multiple other apps with a similar purpose have also been developed and are being developed [14]. Two AI detection tools were evaluated with this paper. The authors are grateful to our colleague, Frank Appun, for bringing these and similar tools to our attention and for conducting the following assessments [15]. The answer generated by ChatGPT to the second discussion board question regarding Defensible Networks was submitted to GPT2 Detector [16]. This tool detects the probability of whether AI has been used to write something. It should be noted that ChatGPT is based on GPT3.5 rather than GPT2. Nevertheless, the GPT2 Detector reported that the response generated by ChatGPT for the Discussion Board question on Defensible Networks cited above had a 99.98% probability of being generated by AI!

The “Originality.AI” [17] plagiarism checker and AI detector was used with the entire paper to assess whether it had been generated by AI. Because some significant parts of this paper include direct quotes of ChatGPT output, it was expected that the result would include a probability that the paper included AI generated material. Originality.AI reported an 80% probability that this paper was generated by humans, and a 20% probability that it was AI generated.

It is important to understand that AI detection tools are not perfect. The tools can generate false positives and false negatives. OpenAI recently announced a tool for detecting text generated by AI, but it does not work almost 75% of the time, and it has a false positive rate of 9% [18]. It is critically important that these tools are not used by themselves. As noted by Klein [19], accusing a student of using AI to write an assignment based on a false positive could do irreparable damage.

4. Students should be encouraged to use AI tools as a collaborator, similar to the way they would collaborate with other students.

Recent technology and capabilities are a given. And this is happening at a very rapid pace. We may view these as challenges to overcome, and concoct ways to restrict them, but as experienced in the past, that course of action is bound to fail. In the past, we have seen this happen with calculators, powerful handheld minicomputers (HP), internet, google, smartphones, and now AI. All efforts to restrict the use of these technologies have, and will, eventually fail and be proven non-practical. These advances had to be accepted for student use and the teaching-learning paradigms had to be adjusted to use them as tools to enhance learning. Similarly, AI capabilities are here to stay; academia needs to accept that and adjust with innovation and creative solutions.

In the not-too-distant past, students were encouraged to work solely as individuals. But, with the advances in technologies, collaboration, and the ability to work in teams has become a high-value quality in the workforce. In fact, one of the top talents demanded by industry is the ability to collaborate and be a team-player. Given that prerequisite, the teaching-learning methods in academia have adjusted accordingly.

Based on the above trends and the fact that AI text generation tools can be powerful collaborators, we should treat these as opportunities and come up with innovative ways to adjust the content, delivery, and the evaluation of student learning. Many are of the opinion that teachers and educators are quickly becoming obsolete. Human experts have demonstrated reasonable control over their AI technologies, and advanced research and competition in this area may produce greater opportunities for harmless use of AI tools in collaborative tasks for promoting learning. As AI capabilities become mainstream, we humans will come up with ways to take the next step. So how do we evaluate the student comprehension and understanding of the subject matter? That is the main question and opportunity facing academia today.

A few possible ways to adjust and fine-tune the course contents, delivery method, and student evaluation in STEM programs include project-based learning [20], evaluation with case studies, hands-on assignments and exams, and labs for project designs and implementations in modern STEM classes. Additional innovative assessment mechanisms may emerge in this area.

Conclusions

Based on our findings and research, the authors have come to four primary conclusions:

- 1) Use of tools such as ChatGPT without acknowledging that they have been used *is* cheating based on the traditional definitions of “cheating.”
- 2) It will be impossible to stop students from using tools like ChatGPT. But the use of such tools can be detected, similar to the ways plagiarism can be detected, albeit with a very high percentage of false positives.
- 3) Use of AI tools should be encouraged as a form of collaboration.
- 4) From an ethical perspective, higher education should focus on new methods and mechanisms for assessing student learning that take advantage of the AI tools to improve student learning.

From the ethical perspective of Utilitarianism [21], unacknowledged use of an AI tool such as ChatGPT to write essays, answer exam questions, write discussion board posts, or to complete many existing types of assignments, is cheating. From the perspective of individual Utilitarianism, students are cheating themselves because use of these tools may prevent students from learning the skills they need to succeed in their careers. From the perspective of universal Utilitarianism, society is being cheated out of having experts with the technical skills society needs to address many critical future issues and problems. Additional ethical implications of cheating in assignments for credit may include harmful impacts on honest students who may

compete for grade-point-average (GPA) based opportunities such as financial aid, assistantships, awards, honor-rolls, admission to graduate programs, etc. Cheating is a form of academic dishonesty, which is ethically unacceptable, and in some contexts, punishable by law [22]. A fair strategy is to make all assignments for credit free from cheating and provide other learning activities modernized with new tools and technologies including AI.

From the ethical perspective of Deontology [23], most would agree that using such tools as ChatGPT goes against the rule of individuals completing work on their own. Although the US Court of Appeals has ruled that machine intelligence such as AI cannot be listed as the inventor on a patent application [24], most would agree that using AI to complete assignments is closely equivalent to having someone other than the student complete their work for them.

Nevertheless, the tools are free at this time and already widely available. Banning their use is not likely to succeed but can be controlled using AI detectors similar to the way plagiarism detectors are already in use. As a result, the focus of engineering education should be on finding ways to assess student progress that demonstrate to students and future employers that students have acquired the skills they need to contribute positively to their professions and to society.

Use of AI tools as a form of ‘Collaboration’ is an extension of the use of tools such as calculators, search engines across the internet, and smartphones. At a minimum, AI tools like ChatGPT may be considered automated technical writers. But they go beyond that. A considerable amount of learning can occur as students use AI tools to help conduct the appropriate research (similar to the way search engines are already used), assembling a set of relevant findings and generating hypotheses. If the AI tool generates additional hypotheses, this can expand student learning. All of this may be fed to an AI tool to create a polished paper or used by the student or group to write a paper themselves. What is learned from an AI tool is similar to learning from each other during a group project.

The difference between traditional collaboration and collaborating with AI tools is that the student is now collaborating with a very knowledgeable, capable, and intelligent machine partner. Collaboration between machines and humans is already widespread in manufacturing, as machines do many tasks that would be dangerous and/or impossible for humans to do. We have accepted collaboration and group efforts among students in the past, and even encouraged it, so now we need to come up with ways to accept “super-collaboration” with AI and extend this collaboration to homework, assignments, quizzes, and exams.

One example of collaboration is the use of AI tools such as ChatGPT as a library source. In many cases students are already accessing libraries digitally. Tools like ChatGPT can help students find information relevant to their projects and their research more efficiently than current methods. To ensure learning, students need to carefully reflect on new information that has been found through their use of AI tools and new insights they may not have thought of by themselves. Such new insights and help can enable them to learn “out of the box.” Students should be asked to reflect on any new insights they have learned when they submit their assignment.

Part of this reflection should include a consideration of potential biases that may be in the ChatGPT dataset. As noted above, GPT was trained on a large amount of text data from a wide variety of sources including books, articles, and websites [8]. Whatever biases exist in these sources may be reflected in the output. This will vary with subject, and students will need to consider whether what they “learn” from AI, in any particular instance, may be influenced by inherent biases in the dataset [25]. Because the dataset is so broad, any such biases will likely reflect widespread biases in contemporary culture.

Society has decided that the use of calculators is good, so long as the student understands the underlying principles of addition, multiplication, subtraction, and division. To ensure that engineering students are acquiring the skills they need to become strong contributors to their professions, assessment mechanisms will need to make increased use of various forms of Problem Based Learning. Several potential examples were given in the Findings section above. Project assignments designed to demonstrate that skills have been acquired will be critical both for students and institutions. There is no “one size fits all” approach that will work, but many creative approaches are likely to emerge.

Final Thoughts

AI tools will continue to become more powerful in the near future. Stakeholders in modern education have to deal with the challenges posed by these tools [26]. At this time, there is no consensus. Every instructor needs to carefully use their judgement about how to use AI tools to promote learning for the topics they are dealing with and consequently students should be encouraged (or not) for utilizing the AI tools. Unless some converging policies emerge in the near future, instructors should be equipped with freedom and responsibility for the topics they teach for the best learning experience. As AI tools become more sophisticated, instructors may have to share their teaching loads with AI tools and in some cases, AI tools may perform better than human teachers. Future AI tools may use effective innovations in teaching that are hard for humans to replicate. Humans adapted to changes adequately in the past; rapid changes in AI will continue to pose challenges that can be serious.

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