ENGINEERS
AUSTRALIA

Ms Lisa Chesters MP
Chair of Standing Committee on Employment, Education and Training
Via Committee Secretariat
PO Box 6021
Parliament House
Canberra ACT 2600

Dear Ms Chesters,

Inquiry into the use of generative artificial intelligence in the Australian education system

The work engineers undertake makes a significant contribution to our society and economy and is vital to overcoming many of the challenges we face. The rapid uptake and changing nature of technology, necessitates a corresponding shift in engineering education. This shift is required to meet industry demands.

Engineers Australia is the peak body for the engineering profession in Australia, constituted by Royal Charter, to advance the science and practice of engineering for the benefit of the community. We are the collective voice of over 115,000 members. As Australia's signatory to the International Engineering Alliance multi-lateral accords, Engineers Australia maintains national professional standards, benchmarked against international norms. We evaluate engineering courses against entry-to-practice competencies to determine whether graduates will meet international benchmarks to practise.

Like many other professions, engineering is not immune from the impact of artificial intelligence (AI). AI can be applied in many ways, such as to help optimise the design process, improve modelling, increase the productivity of production processes, enhance robotics and extract more meaningful analysis from data. For the engineers of tomorrow, it is critical to enable a learning environment which promotes and teaches students how to use these rapidly evolving technologies. It also provides new, personalised learning opportunities, helping students to reach their full potential by aiding in the tailoring of education programs to individuals, providing new analytical tools to identify gaps in their knowledge and understanding.

While the benefits of AI in education potentially outweigh the risks, it is important to consider the negative impact AI could have. A critical aspect of learning is the acquisition of tacit knowledge. To obtain this level of knowledge requires grasping foundational concepts, understanding the underlying principles and then applying them practically. To build this effectively, students must invest time, actively participate in discussions and engage in hands on activities. Developing tacit knowledge is particularly important in courses such as engineering. Engineering education is hierarchical. Students need to have a solid grasp of base principles before moving on to a more complex concept. The use of AI and particularly generative artificial intelligence may hinder a student's ability to demonstrate their aptitude in understanding critical concepts.

Engineers Australia's submission provides feedback on the terms of reference focusing on how Generative AI tools will impact engineering education. If you wish to discuss this further, please contact Michael Bell, Senior Policy Advisor, at mbell@engineersaustralia.org.au or on +61 8 6214 6321.

Regards,

Damian Ogden
Group Executive, Policy and Public Affairs

Terms of reference

The strengths and benefits of generative AI tools for children, students, educators and systems and the ways in which they can be used to improve education outcomes.

Generative AI has many benefits in education. As the technology develops and becomes more reliable, Generative AI will support people from all backgrounds in their education journey. It has the potential in the future to provide tutoring experiences to all, no matter an individual's socio-economic background. With the release of ChatGPT many focused on the potential harm this technology could cause, particularly around its ability to pass tests. However, as time passes, many are re-evaluating the place chatbots can have in our education system.

As academics investigate using AI in the classroom, a brighter side of the technology is revealed. Generative AI utilising large language models (LLMs) like ChatGPT are being adopted to aid educators, particularly in areas where the technology can improve productivity. One example of this is the use of AI to implement effective teaching strategies.[1] Research out of the United States has shown five ways generative AI can improve the learning environment. These strategies include:

1. Using AI to produce many varied examples
2. Using AI to provide multiple explanations
3. Using AI to develop low-stakes tests
4. Using AI to assess student learning
5. Using AI to distribute practice of important ideas.[2]

By utilising the technology correctly, it can support educators to enhance the development of critical thinking skills in students. It will also allow for under resourced teachers and lecturers to develop a greater number of activities and problems for students to work through. This can be enhanced by developing learning activities to problems which are based on a student's current understanding, established through prior success and misunderstandings. [3]The research concluded generative AI can be a useful tool, when implemented carefully and with thought.[4]

Another recently published paper analysed the use of ChatGPT in engineering education.[5] The authors of this paper examined how ChatGPT may affect assessment in engineering education by exploring ChatGPT responses to existing assessment prompts from ten subjects across seven Australian universities. The authors hinted at the potential opportunities for using ChatGPT to support learning and the development of critical thinking.

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[1] Mollick, E and Mollick, L. 2023 'Using AI to Implement Effective Teaching Strategies in Classrooms: Five Strategies, Including Prompts' *Wharton School of the University of Pennsylvania & Wharton Interactive* (accessed 3 June 2023) https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4391243

[2] ibid

[3] Menekse, Muhsin. 2023. 'Envisioning the future of learning and teaching engineering in the artificial intelligence era: Opportunities and Challenges' *Journal of engineering education* (accessed 3 June 2023)

[4] Mollick, E and Mollick, L. 2023 'Using AI to Implement Effective Teaching Strategies in Classrooms: Five Strategies, Including Prompts' *Wharton School of the University of Pennsylvania & Wharton Interactive* (accessed 3 June 2023) https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4391243

[5] Sasha Nikolic, Scott Daniel, Rezwanul Haque, Marina Belkina, Ghulam M. Hassan, Sarah Grundy, Sarah Lyden, Peter Neal & Caz Sandison. 2023 'ChatGPT versus engineering education assessment: a multidisciplinary and multi-institutional benchmarking and analysis of this generative artificial intelligence tool to investigate assessment integrity' *European Journal of Engineering Education* (accessed 2 June 2023) https://doi.org/10.1080/03043797.2023.2213169

Generative AI can further assist in the education process by providing students more tailored responses. While caution is needed (discussed further in the challenges section), it provides an avenue for students to gain a deeper understanding of a topic and to utilise it to evaluate and assess their understanding.

More broadly, Generative AI is likely to become a productivity tool, and student engineers will need to become trained in its ethical and productive use during their education in accredited programs. This will be critical to foster their understanding of using these technologies and improve their readiness for the workforce.

The future impact generative AI tools will have on teaching and assessment practices in all education sectors, the role of educators, and the education workforce generally.

Like all technology-based resources, the quality of the output from a Generative AI tool depends on the quality of the input parameters provided. Currently, anecdotal evidence suggests that when a student doesn't have a reasonable grasp of the material, they are unlikely to be able to generate quality responses. It is expected educators will be able to develop skills to detect this weakness.

Over time, Generative AI will improve in its ability to provide results that are indiscernible from a human author. This will be the case as future versions are trained on larger data sets. Therefore, its effective and ethical use will require the development of assessment methodologies that can identify and evaluate the capability of the human contribution. The response to the use of Generative AI at an institutional and individual level is already varied. For example, as of June 2023, several engineering schools/faculties were focused on preventing cheating and moving back towards monitored in-person written exams, while others have determined that this assessment approach will never again be implemented.

In terms of detecting the use of Generative AI in an assessment, some universities are taking formal actions, while others are using it as an opportunity to speak with the students in an informal way and provide some guidance on the ethical use of these tools. One university found that the use of an AI detection tool contributed to at least half of the academic integrity cases, while another found very few cases were detected. Many are considering the re-introduction of oral assessments to overcome this.

These technologies provide a unique opportunity to review how students are assessed and develop methods that not only mitigate the potential for cheating, but also develop critical thinking skills. Most of the intended learning outcomes in current curricula were developed prior to the very rapid growth in the use of Generative AI. There is an urgent need for educators to consider if the learning outcomes they have currently in place are still relevant and if it assesses students in a way that legitimately tests their actual capability.

As an accrediting body with an outcomes-based accreditation system, Engineers Australia will want to be assured that the assessment processes used in accredited programs are able to reliably verify student learning and capabilities, given the accessibility of Generative AI. The observations of the Engineers Australia accreditation teams are institutions are dealing with the verification of student learning in different ways. Standards that are built for purpose in addressing Generative AI will be critical for addressing this.

The risks and challenges presented by generative AI tools, including in ensuring their safe and ethical use and in promoting ongoing academic and research integrity.

Many of the opportunities created by using Generative AI, face risks and challenges. The two main concerns stem from the fact Generative AI can produce inaccurate or incorrect information (often while sounding like an authority) and the potential use of the technology for cheating.

Misleading, biased, incorrect or inaccurate information

Generative AI which utilise large language models are trained on large amounts of data. Due to the way the technology works, and its ability to produce natural language, users may incorrectly think the technology comprehends the information. However, large language models utilise the training data to develop sequences of linguistic forms according to probabilistic information about how they combine, but without any reference to the meaning.[6] This was defined in a research paper produced in 2021 as a stochastic parrot.

In addition, it is important to consider that any bias that exists in the training data for tools like ChatGPT will be replicated in responses from the tool. A good example of this was the AI/ machine learning tool utilised by Amazon, which had to be discontinued when it realised the technology was showing a bias against women.[7] The reason for this was because the system had been trained based on observing patterns in resumes over a 10-year period. Most of the resumes over that period came from men due to the tech industry being male dominated.[8] Because of this, the system learnt male candidates were preferred. While Amazon was able to edit the program to make it more neutral to these terms, it highlights the unforeseen consequences of the training data. There is a risk that misinformation can be spread in a much faster and ubiquitous way than is currently the case.

This poses significant concerns to educators as well as academic and research integrity. Caution is recommended in relying on the information provided by these tools. This is particularly important for educators who are relying on these technologies to assist with improving the learning environment. If they are not subject matter experts, they need to verify the information being provided. An example of a risk in this regard is out of subject teachers, utilising these tools to help them prepare learning activities on topics they don't fully understand.

Academic integrity

While generative AI had been around for some years, the release and wider take up of ChatGPT saw the response in Australia and abroad to be similar.[9] State Governments banned the use of the tool in public schools, as did many other tertiary institutions. This was due to much of the early information being distributed focussed on how the OpenAI platform could receive good marks in tests. This raises understandable concerns around students cheating on tests, or not referencing material developed by AI.

In a recent study specific to engineering education the authors explored ChatGPT responses to existing assessment prompts from ten subjects across seven Australian universities and found ChatGPT could

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[6] Emily M. Bender, Timnit Gebru, Angelina McMillan-Major, and Shmar-garet Shmitchell. 2021. 'On the Dangers of Stochastic Parrots: Can Language Models Be Too Big? . In Conference on Fairness, Accountability, and Transparency (FAccT '21)', March 3–10, 2021, Virtual Event, Canada. ACM, New York, NY, USA, 14 pages. https://doi.org/10.1145/3442188.3445922

[7] Dastin, J. 2018. 'Amazon scraps secret AI recruiting tool that showed bias against women' *Reuters* (accessed 5 June 2023) https://www.reuters.com/article/us-amazon-com-jobs-automation-insight-idUSKCN1MK08G

[8] ibid

[9] Heaven, W. 'The education of ChatGPT' *MIT Technology Review Volume 126 Number 3* (May/June 2023)

generate passable responses to many of the assessments.[10] Furthermore, in two recent studies in a medical context, ChatGPT's responses were only weakly distinguishable from those generated by a real person.[11]

While this technology may make it easier in some instances for students to cheat, having a good understanding as to why students cheat, regardless of the tool that is used, is paramount to establishing robust environments to achieve academic integrity. Tools, such as ChatGPT can be used to level up the playing field and may result in less cheating if used skilfully by the educator.

Caution should also be taken against the use of AI detection tools, until there can be assurance, they are developed to deliver a sufficient level of robustness. There is currently a danger that false positive detections will lead to unfair accusations of cheating. This could have implications for the psychological safety of those who are accused.

There is merit in considering professional attributes such as integrity further. Universities play a critical role in developing underpinning values and behaviours of future professionals. As an accrediting and assessing body, Engineers Australia establishes the professional standards framework for practice in Australia - including ethical behaviour. There are mechanisms that universities and professional bodies can leverage to guide an individual's values and behaviour to act appropriately and ethically when using these technologies.

Lastly, we spoke of many benefits to aiding in a student achieving knowledge in a particular subject. However, the quick uptake of these technologies means we don't know the risks to learning and cognition from the utilisation of these tools. The education sector needs to focus on ensuring students develop tacit knowledge in their field of study. Urgent and quality research is required in this space to provide evidence on generative AI's efficacy in Learning and Teaching.

Other risks and challenges

Risks and challenges around accuracy of information and academic integrity are critical. However, other risks and challenges need to be considered in the form of privacy and data protection. Inputting students' personal information into these systems could expose them to security breaches and cyber risks. The future use of the data is also not known, with the potential for future systems to use input data for further upskilling. Caution needs to be taken by organisations to ensure they are adhering to privacy and other legislation, particularly when using the information on minors.

How cohorts of children, students and families experiencing disadvantage can access the benefits of AI.

Over time, generative AI can bridge the education gap for those experiencing disadvantage, by providing access to information in a more personalised and streamlined way. While the risks around accuracy of

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[10] Sasha Nikolic, Scott Daniel, Rezwanul Haque, Marina Belkina, Ghulam M. Hassan, Sarah Grundy, Sarah Lyden, Peter Neal & Caz Sandison. 2023 'ChatGPT versus engineering education assessment: a multidisciplinary and multi-institutional benchmarking and analysis of this generative artificial intelligence tool to investigate assessment integrity' *European Journal of Engineering Education* (accessed 2 June 2023) https://doi.org/10.1080/03043797.2023.2213169

[11] See (2) Oded Nov, Nina Singh, Devin M. Mann. 2023. 'Putting ChatGPT's Medical Advice to the (Turing) Test. *medRxiv* https://doi.org/10.1101/2023.01.23.23284735
(3) Adam Hulman, PhD, Ole Lindgård Dollerup, PhD, Jesper Friis Mortensen, MSc Matthew Fenech, PhD, Kasper Norman, MSc , Henrik Støvring DMSc, Troels Krarup Hansen, DMSc. 2023 'ChatGPT versus human-generated answers to frequently asked questions about diabetes: a Turning test-inspried survey among employees of a Danish diabetes center' *medRxiv* (accessed 5 June 2023) https://doi.org/10.1101/2023.02.13.23285745

information limits this ability now, it is expected that these technologies will only become more and more accurate over time.

Prompt engineering is to optimise the inputs and application of a Generative AI tool to illicit an accurate answer. It is a skill that has been gaining traction and highlights that the most effective use of Generative AI is gained when those seeking the information have achieved a level of expertise in its use and understand how to construct appropriate input parameters. Therefore, to make the most effective use of Generative AI, or indeed AI more generally, those from disadvantaged backgrounds will require educative resources to support their learning in its effective, appropriate and ethical use.

International and domestic practices and policies in response to the increased use of generative AI tools in education, including examples of best practice implementation, independent evaluation of outcomes, and lessons applicable to the Australian context.

The authors of the research paper 'ChatGPT versus engineering education assessment: a multidisciplinary and multi-institutional benchmarking and analysis of this generative artificial intelligence tool to investment assessment integrity' by Nikolic et al. (2023) sought to understand the potential impact of ChatGPT on the integrity of engineering education assessment and answer the question "How might ChatGPT affect engineering education assessment?"[12]

The strengths and weaknesses of current assessment practice were explored and opportunities to use ChatGPT to facilitate learning were proposed. The paper provides a snapshot in time of ChatGPT's performance as of early 2023 in responding to engineering education assessment prompts. This paper has been referenced several times in our response.

A second piece of research 'Envisioning the future of learning and teaching engineering in the artificial intelligence era: opportunities and challenges' by Muhsin Menekse (2023) is also referenced in this submission and provides excellent information on the benefits and challenges with using this technology in engineering education.[13]

In the United States, where the initial reaction was similar to here, many universities and schools are starting to look at this technology as a gamechanger and integrating it into the learning environment. These technologies are being rolled out in many forms within industry, and for students to be competitive and have skills needed by employers, it is vital they get a grasp on them during their studies.[14] Research by the Walton Family Foundation in the United States looked at teacher and student attitudes toward ChatGPT from kindy to year 12. Key findings from this research showed 51 per cent of teachers reported using ChatGPT within a few months of its release.[15] In addition, 75 per cent of students reported ChatGPT helped them learn faster, with 73 per cent of teachers agreeing.[16] The research also found 71 per cent of

[12] Sasha Nikolic, Scott Daniel, Rezwanul Haque, Marina Belkina, Ghulam M. Hassan, Sarah Grundy, Sarah Lyden, Peter Neal & Caz Sandison. 2023 'ChatGPT versus engineering education assessment: a multidisciplinary and multi-institutional benchmarking and analysis of this generative artificial intelligence tool to investigate assessment integrity' European Journal of Engineering Education (accessed 2 June 2023) https://doi.org/10.1080/03043797.2023.2213169

[13] Menekse, Muhsin. 2023. 'Envisioning the future of learning and teaching engineering in the artificial intelligence era: Opportunities and Challenges' *Journal of engineering education* (accessed 3 June 2023)

[14] Heaven, W. 'The education of ChatGPT' *MIT Technology Review Volume 126 Number 3* (May/June 2023)

[15] 'Exploring teacher and student attitudes toward ChatGPT' *Walton family Foundation* (4 May 2023) https://www.waltonfamilyfoundation.org/stories/k-12-education/exploring-teacher-and-student-attitudes-toward-chatgpt

[16] 'Exploring teacher and student attitudes toward ChatGPT' *Walton family Foundation* (4 May 2023) https://www.waltonfamilyfoundation.org/stories/k-12-education/exploring-teacher-and-student-attitudes-toward-chatgpt

teachers and 65 per cent of students agreed that generative AI tools will be essential for students future success, both academically and in the workplace.[17]

Recommendations to manage the risks, seize the opportunities, and guide the potential development of generative AI tools including in the area of standards.

Engineers Australia recommends the development of standards on how Generative AI can be used to develop critical thinking and evaluative judgement should be an immediate focus. Unfortunately, the pace of change will make it hard for these standards to be maintained. Therefore, it would seem essential to develop a standards framework that has adaptability as its core, some examples of what could be included:

- Development of education around generative AI:
  - fundamental principles on effective and ethical engagement with generative AI
  - appropriate acknowledgement of, and guidance on how to evidence critical engagement with generative AI tools
  - development of prompt engineering skills to enable generative AI to be used to develop critical thinking skills and evaluative judgement,
  - tuning learning outcome specifications to the generative AI era,
  - assessment designed to test human capability. ie. why would something that can be generated by AI be assessed? – a more robust assessment might require the student to critique the responses from a tool like ChatGPT.
- Ethical implications of uploading student work for assessment.

The student voice will enable the development of standards that meets their needs, therefore the establishment of a student reference group to help define and maintain the standards is crucial.

In the future, we are likely to see the development of discipline-specific Generative AI tools, which are not only trained on a generalised large language model, but specifically in a discipline ecosystem. The development of guidelines on how these tools should be developed and utilised to ensure some standardisation would be useful. For example, appropriately declared use/acknowledgement of Generative AI tools, just as is the case with referencing the use of published work of others, needs to be a critical element in the developing ethical attitudes and practices for graduates entering any field of professional practice.

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[17] ibid