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# The Effects of AI Feedback on Students' Epistemic Emotion and Performance in Engineering Design: An Exploratory Study

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**Abstract:** One of the affordances of AI (Artificial Intelligence) for professionals is that AI can explore a much wider solution space to arrive at creative solutions that surprise them. This study explored the epistemic emotion of surprise and its effect on students' performance as they used AI feedback to assist their engineering design. Specifically, we examined 43 high school students' emotional reactions and their changes in design solutions after receiving AI feedback. Multinominal regression was performed to find that AI feedback did not have a significant influence on the level of surprise students experienced. However, most students made more positive changes to their designs when they found that AI feedback was much better than their original solutions. This study suggests that integrating AI elements in engineering design could help students optimize their designs.

## Introduction

There is a trend of integrating AI elements into STEM (i.e., science, technology, engineering, and mathematics) education for cultivating students' cross-disciplinary knowledge and creative thinking to solve authentic problems in real life. However, students find it challenging to understand how AI works and how AI feedback could benefit their learning process (Touretzky et al., 2019). This is particularly true in the context of engineering design. Engineering design involves the integration of relevant STEM knowledge and the constant development of design outcomes (Zheng et al., 2020), during which surprise may occur and may affect students' iterative modification and refinement. However, there is limited research exploring students' epistemic emotions in engineering design. Thus, this study aims to examine the occurrence of the epistemic emotion of surprise and its effect on students' learning and performance when they use AI feedback in engineering design.

## Methods

**Figure 1**
*Interface of Aladin*


This is part of a larger study where 43 students from two suburban Midwestern high schools learned science concepts, performed engineering design, and utilized AI feedback in a simulated learning environment (i.e., Aladdin). In the current study, students were asked to redesign a profitable solar farm, which generated more annual revenue from the produced electricity and less annual cost caused by installing and maintaining solar panels. In Aladdin (see Figure 1), students can have access to a variety of construction, visualization, and analysis tools (Zheng et al., 2020). More importantly, AI feedback leads students toward a comprehensive understanding

 

of all design variables. The AI feedback is produced through an evolutionary computation process that systematically searches through various variables or parameters to identify optimal solutions under certain criteria and constraints (Xie et al., 2022). As displayed in the bottom left of Figure 1, the AI presents a dynamic graph to show how AI achieves the optimal design through a series of evaluations and generations. Students were encouraged to refine their designs after receiving AI feedback. We then used two open-ended questions to examine students' feelings of surprise. i.e., *If you are surprised by how AI changed the design variables, can you explain why? If you are not surprised by how AI changed the design variables, can you explain why you are not surprised?* To categorize students' responses, we designated them as "surprised" if they reported solely surprised variables, "not surprised" if they reported exclusively unsurprised variables, and "partially surprised" if they indicated surprise towards some design variables but not others. Finally, students' performance change was calculated by subtracting the student's final design profit (after receiving AI feedback) from the student's original design (before receiving AI feedback).

## Results

After receiving AI feedback, most students were partially surprised (N = 24). However, some other students felt either not surprised at all (N = 8) or totally surprised (N = 11). Students felt totally surprised when the AI design was much better than their original design, whereas some other students were not surprised when the AI design only made a slightly more profit or made the same profit. For example, student CP5S9 said, *"I am surprised because I didn't realize how much the tilt angles could change through the seasons. There is a sort of spot that is the greatest, but that more appropriately has the tilt angles."*. In contrast, student *CP5S7* commented*, "I am not surprised because the AI did not change anything to my final design."*. In addition, we found that students' performance change was positively correlated with AI feedback. The majority of students made more positive changes to their design when they found that AI design was much better than their original design.

## Discussion and conclusion

This study explored the epistemic emotion of surprise and its effect on students' learning and performance when they received AI feedback in engineering design. We found that AI feedback did not have a significant influence on the level of surprise students experienced. This unexpected finding may be due to students' different epistemic beliefs on AI feedback. Students' epistemic belief is a significant antecedent of epistemic emotions (Muis et al., 2018). Students who valued AI feedback would be surprised when AI provided limited design suggestions about their design. Meanwhile, students who had high belief in their original design may not feel surprised at a mild change made by AI.

Furthermore, most students made more positive changes to their design solution when they found AI feedback was much better than their original solution, whereas a few students failed to make significant changes to their final design. This finding suggested that a larger change made by AI induced more effort from students in iterative design and better final performance. Therefore, instructors and designers should present AI feedback in a way that highlights the improvement made by AI to maximize its utility. In addition, some students still need assistance in understanding AI feedback and making corresponding changes to their original design. This suggests the necessity to increase students' AI literacy so that students can use AI feedback effectively (Long & Magerko, 2020). In summary, the findings of this study corroborate the effectiveness of AI feedback on students' design performance, regardless of the level of surprise experienced by students. More research is needed to investigate the interplays of epistemic beliefs, epistemic emotions, and AI feedback in engineering design.

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