Critical Thinking Strategies in Engineering Education: Review and Recommendations

Ethan M Rosenberg, University of Maryland, College Park

Ethan Rosenberg, an undergraduate at the University of Maryland, College Park, majors in mechanical engineering. He is also receiving a citation from the Public Leadership College Park Scholars program. He is also a member of the aerodynamics team for Terps Racing, and has specialized in developing and simulating aerodynamic components. He has also worked on improving the simulation methodology used to gather more accurate results. Ethan has mentored new members and worked to foster an encouraging and productive environment.

Dr. Mohammad Fazelpour, University of Maryland, College Park

Dr. Mohammad Fazelpour is a senior lecturer in Mechanical Engineering at the University of Maryland, College Park. He joined the university in 2017 as an assistant clinical professor and research educator for the Designing Innovation Research Stream, where he advised first-year and sophomore students on design research methodologies. In 2018, he transitioned to the Department of Mechanical Engineering to teach design-related courses, including computer-aided design and machine design. Additionally, he introduced a new course focused on design for manufacturing and assembly. Dr. Fazelpour's active engagement in professional organizations includes membership in ASME and ASEE. He has held various leadership positions within the ASME Design Education Committee from 2019 to 2023, including roles as program chair and committee chair. His research interests primarily focus on design education and pedagogy.

Dr. James Righter, The Citadel

James Righter is an Associate Professor of Mechanical Engineering in the School of Engineering (SOE) at The Citadel. He earned his BS in Mechanical Engineering at the U.S. Naval Academy, his MS in Military Studies from the Marine Corps University Command Command and Staff College, and his PhD in Mechanical Engineering from Clemson University. His research interests include engineering leadership, design methods, engineering design education, and manufacturing.

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Critical thinking and its importance

Critical thinking (CT) is often thought of as an umbrella term that encompasses a number of different skills. According to one scholar, students must be able to design experiments, understand data, create products that meet requirements, act in an ethical manner, and grasp the impact of their engineering solutions in order to excel at critical thinking [1]. Not all scholars have the same definition of critical thinking. A different scholar agrees that understanding information is still an important part of critical thinking, but they also emphasize the importance of being able to communicate information with others [2]. They also highlight the importance of being able to apply these skills not just while creating solutions, but also while understanding experiences [2].

For this paper, critical thinking will be defined using the definition coined by Michael Scriven and Richard Paul in a presentation from 1987. While this is an older definition, this ideology still aligns with the overarching themes of other scholars today. They state that critical thinking is "the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action" [3]. This framework looks to promote a set of information and belief generating skills while also developing the habit of using these beliefs and information to guide decisions. This contrasts with other methods of learning in which students may seek to simply retain information instead of attempting to generate further knowledge from it. This generation of further knowledge will allow the student to use the knowledge they have learned in contexts that differ from that in which they learned it. It also looks to familiarize students with using critical thinking skills in day-to-day life, rather than having them learn the skills but never apply them.

Major international education bodies, such as ABET, consistently make recommendations that critical thinking instruction should be embedded into instruction with other generic engineering competencies [4], [5]. This idea is also founded in the thoughts of students where one study conducted showed that a majority of engineering education students recognize the importance of critical thinking in their field [6]. They also acknowledged that having these skills helped not only in their studies, but also prepared them for future careers and enhanced their employability [6]. Other research argues that critical thinking skills are one of the most important things in formal education because of the rapidly accelerating rate of the creation of new knowledge [7]. Besides bodies such as ABET, students and professors also believe that critical thinking is important in higher education. In one study that was conducted on faculty, more than 80% of faculty believed that critical thinking should be included in their teaching [8]. In addition to this, 100% of faculty that responded to their survey indicated that they included critical thinking in their courses. Despite these numbers, roughly 10% indicated that they do not believe that critical thinking happened despite its inclusion [8]. Furthermore, roughly 12% of respondents stated that they do not monitor, nor assess, critical thinking as part of their course [8]. Students also believe that critical thinking is an important skill to develop, with a majority of respondents for a different study stating that they recognize its importance and that it can prepare them for future success [6].

Perspectives on Critical Thinking Shifted Over Time

Perspectives on critical thinking have shifted majorly over time, starting out as unimportant and slowly developing into what we see today. The term critical thinking was first used by philosopher John Dewey in 1910 [9]. He would also commonly call this term reflective thinking. He defined this term by stating that it was "Active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends" [10]. Even though definitions still vary today, this is still similar to many definitions with one stating that it is "engagement with problems that requires identifying and questioning assumptions, integrating knowledge, and applying these assumptions and knowledge to solve a problem" [11]. While these two definitions use different language, they have extremely similar meanings.

Even though the term critical thinking has existed since 1910, that doesn't mean that it was as prominent of a term as it is today. Throughout the nineteenth and twentieth centuries, the terms systems thinking was gaining popularity [12]. While this is not the same as critical thinking, it did serve a role as a replacement for it. Systems thinking was the idea that any individual machine was not in fact an individual machine, but was instead a system of many smaller components that combine to form the machine as a whole [12]. This ideology was critical during the development of new communication methods, electricity, space exploration, and much more.

According to a paper written in 2002, critical thinking had been increasingly emphasized in higher education [11]. Despite this overall increase, the author claims that there has been much less emphasis on critical thinking in engineering education [11]. Around this time, ABET changed their criteria for accreditation. They included harder to achieve learning outcomes such as students understanding the global context of their work and the ability to engage in lifelong learning [11]. According to ABET itself, the new criteria shifted the focus from what was taught to students, to what was learned by students [13]. After implementing these new criteria, ABET performed a study on how this affected engineering education. They found that in the majority of cases, programs began to emphasize critical thinking skills as well as activities that could help promote critical thinking growth [13]. They still did not explicitly use the term critical thinking, but schools were now promoting it more in classes.

Critical thinking in engineering education literature review

There have been numerous studies that examine how effective different strategies were in promoting critical thinking growth. These methods can take different forms such as pretraining students to enable them to apply critical thinking during the course [14], incorporating Artificial Intelligence (AI) into engineering courses [15], [16], [17], incorporation critical thinking activities into engineering courses [1], [18], [19], and changing teaching methodologies to encourage students to think critically through student centric education [2], [7], [20], [21], [22], [23], [24]. There have also been a number of different methods for obtaining results. These methods include testing students before and after the course [2], [20], [21], [23], comparing post course results to a control group [14], [18], measuring student responses to a survey [6], [7], [15], [16], [19], and having students give open feedback through a journal or a focus group [17], [22]. The methods to promote critical thinking growth will be evaluated based on their effectiveness at promoting critical thinking growth. The methods to measure such growth will be evaluated by the quality and precision of their results.

Methods to promote critical thinking growth

There have been different methods used to promote critical thinking growth in engineering education. The methods that will be discussed here are pretraining students prior to taking the course [14], incorporating AI into the course [15], [16], incorporating critical thinking activities into the course [1], [18], and changing teaching methods to encourage critical thinking growth [2], [7], [23], [24].

Pretraining students methodology focuses on pretraining students for an engineering drawing course and it incorporates higher order thinking skills into the pretraining. This paper defines higher order thinking skills as the skills that are used during open ended discussions, inquiry-oriented experiments, and evaluating real world problems in a classroom environment [14]. They further argue that the development of these higher order thinking skills would benefit in the development of students' critical thinking abilities [14]. This research concluded that there was a statistically significant difference in the average scores that students achieved when they received pretraining in higher order thinking. This suggests that pretraining is an effective tool for promoting critical thinking growth.

Incorporating AI into engineering courses has had mixed results in the studies that examined it. Prior research concluded that students' use of Chat GPT helped to promote analytical thinking [16]. A similar study also had promising results with 64% of respondents stating that generative AI tools significantly improved their critical thinking ability [15]. In addition to providing student feedback, personal thoughts are given about generative AI stating that it is able to help improve students' ability to analyze, evaluate, and synthesize information [15]. Contrary to these findings, other research has shown that over-reliance on AI tools can lead to the user reducing their independent analysis of information [17]. Even papers that find benefits from AI use cite negatives, with one author citing ethical challenges and biases in AI algorithms that must be addressed [15]. Other scholars have different concerns about AI use and critical thinking, with one stating that improper use of generative AI can be a hindrance when attempting to develop critical thinking skills [25]. This remains a highly debated topic within the academic community, and further empirical research is required to substantiate the potential benefits and drawbacks of AI usage.

A third methodology that was implemented was the incorporation of critical thinking activities into the course. The foundational idea behind this methodology is the fact that when students graduate and join the workforce, they will then be required to adhere to industry standards and be able to work with real world problems [1], [18]. These real-world problems force students to examine problems in different contexts, and this can help them grow critical thinking skills [19]. This strategy has also had experimental testing that demonstrates its effectiveness, with one study concluding that over half of the students who participated felt that these activities helped them better understand what was taught in class while also demonstrating how the theories they had been taught could be used to solve problems. Students also had ideas on how this strategy could be improved, with roughly one third of student respondents stating that having a critical thinking activity to go with each major topic would be beneficial for deepening their understanding [19]. A different paper on this topic stated that in having these activities, the students could be required to justify their decisions, thus promoting strong communication skills and deepened reasoning [1].

The final methodology that will be examined in this review is an altering of the currently applied teaching methods to make courses more student centered. This method has been supported by multiple researchers, with one stating that if a professor were to use appropriate teaching methods, and chose appropriate content to teach, then the critical thinking ability of students would improve [2]. It concludes that the correct teaching methods are focused on student centered learning [2]. Other studies promote a similar but different approach, instead opting to focus on inquiry-based learning [7], [21], [22]. Inquiry learning is still student centric learning, but there is a larger emphasis on the exploration of knowledge [21]. This exploration process is designed to facilitate the development of problem-solving skills. Other studies have been conducted to determine the effectiveness of this strategy, and they have found that this strategy is effective for promoting critical thinking [22]. In an intersection between this strategy and that discussed in the previous paragraph, one researcher sought to both change the teaching model as well as incorporating hands-on critical thinking activities [20]. Over the course of the semester, students were more successful in this course, indicating that it was effective at improving critical thinking and reasoning skills. Another method to improve students' critical thinking skills was through the incorporation of the engineering design process [23]. The engineering design process includes steps such as identifying a problem, designing a solution, prototyping this solution, and evaluating the effectiveness of the proposed solution. Research has shown that incorporating this learning model into a course can help promote more positive student outcomes [23]. One such outcome that can be improved is critical thinking skills, where students who had taken the course received a rating of very high on a critical thinking test conducted by the researcher. All students in this experiment experienced significant improvement compared to the testing that had been done prior to the course [23]. Some studies have also experimented with creating textbooks that aim to encourage critical thinking [26]. These studies have found these materials to be effective in achieving their goals.

Table *1* summarizes selected literature addressing critical thinking in engineering education and includes a characterization of the intervention method used, the method results were obtained with and the course subject. The intervention methods are characterized as pretraining (P), incorporating AI (A), incorporating critical thinking skills (C), and changing teaching methods (T) consistent with the definitions provided above. Pretraining and incorporating AI skills are the least frequent in the selected papers with three instances each. All of the three AI related papers were published in 2024 or 2025, indicating a current trend in AI research. The assessment methods are distributed relatively evenly with a mix of surveys (S), free response (F), repeated measures (R), and independent samples (I). The selected papers were published between 2001 to 2025, spanning a 25-year period. The papers covered studies in a variety of disciplines spanning civil engineering to computer engineering, and sciences including physics and chemistry. Only two of the papers addressed critical thinking in engineering graphics or computer aided design specifically, indicating a possible benefit to future efforts in these subject areas.

What Methods Have Been Employed to Evaluate Critical Thinking Growth

Many methods have been used to evaluate the effectiveness of critical thinking. The methods focus on comparing one group of students before and after the course or other intervention [2], [20], [23], comparing the results of the students who received the intervention with a group of students who did not [14], [18], examining student responses to a survey [6], [7], [15], and having students provide open feedback on the course through a journal or focus group [17]. All of these methods can be effective to some extent and may complement one another in determining experimental results, depending on the context and the specific features being examined.

The first method that will be examined is comparing students before and after the course. This methodology lends itself to doing statistical analyses on the data that is obtained. These analyses can include paired T-tests, ANOVA tests if there are enough sample groups, and least significant difference tests [21]. This methodology is also good for detecting differences inside of a sample group. This can be accomplished by comparing scores or other data that was obtained between the two groups to detect a difference. If something is being timed, this can help determine if there is a statistically significant difference between the two groups. This method can also be used to demonstrate improvements within a sample group. There may be data that seems insignificant on its own, but if you examine this data before and after the experiment you are able to compare the two and see statistically significant differences [23]. A common test that is used for this is the California Critical Thinking Disposition Inventory [2]. This test is a widely used method for measuring critical thinking and is suitable for college students and adults in the workforce. This test can allow researchers to determine how advanced the subject's critical thinking skills are. This information can be compared before and after the course, and this can show a growth in critical thinking skills [2]. A similar way this can be conducted is by examining students' growth over time. This can be done by examining exam scores [20]. Changes in the trends of these scores can display a growth, or lack thereof, in critical thinking skills.

Another strategy that has been employed to evaluate the effectiveness of courses is doing post course testing on students and comparing that to students who received traditional teaching methods. This can be beneficial because this allows researchers to see the differences between the new course and the original teaching methods instead of solely seeing if it was effective or not. This is important because it removes the fact that traditional teaching methods may have been just as effective, but it still appears to be an effective method because of the growth in students' critical thinking skills. When comparing these two groups, there are a number of statistical methods that can be used and they can demonstrate a statistically significant difference [14]. This method can also be combined with pre and post-tests to give more results to examine [18]. These additional data points can facilitate drawing more comprehensive conclusions from the available information.

Some research opts to use student feedback to a survey as a means to gather information on the course. This can be used to gather general information on how the students felt about the course

[7], [16]. This can also be used to make revisions on the course. Students may give feedback on what they feel would be helpful for their learning, and this can then be implemented in future semesters of the course [6], [19]. Students can also directly give reports on their thoughts of how this course affected critical thinking [15]. This can allow researchers to see not just if the course helped statistically, but if the course helped the students' perception. Surveys can be a very useful tool to gather students' feedback and perspectives, but it lacks the numerical evidence that other methods may provide.

The final method that was used to evaluate student feedback was allowing students to give more open-ended responses through journaling or having focus groups. Both of these methods were used together in one study and this allowed the researchers to evaluate both the growth of the students over time as well as the end results [17]. Using these methods in tandem gave the researchers insight into how students' perception changed over time and with each activity. The other study only had focus groups and did not have students fill out journals. This methodology was used to help the researchers refine the course [22]. This allowed student feedback to play a larger role in how the course would look in future semesters.

Computer aided design (CAD) course with activities that promote critical thinking

The introductory CAD course promotes critical thinking through a progression of hands-on, design-centered, and real-world activities integrated throughout the semester. Students begin by analyzing physical and everyday objects to produce engineering drawings, supporting the development of spatial interpretation and higher-order observation skills. As they advance, they tackle open-ended design challenges such as creating ADA-compliant staircases, designing realistic crankshafts, and developing a phone stand with a purposeful failure point—activities that require researching standards, interpreting constraints, evaluating alternatives, and justifying design decisions. Systems thinking is strengthened through assembly-focused tasks where students must integrate multiple components into functional mechanisms, connect non-collinear pipes with proper geometry, and animate multi-part systems to achieve specific outputs. Analytical and predictive reasoning are emphasized in finite-element-analysis assignments, where students compare mesh sensitivities, reason about deformation trends, and make trade-offs between weight, cost, material properties, and performance in component design. Across these activities, students consistently practice design justification, decision-making, prediction, evaluation of system interactions, and optimization under constraints—core elements of critical thinking—while becoming proficient with increasingly complex CAD tools and engineering workflows.

Discussion on Promoting Critical Thinking in Other Courses

Research has shown that encouraging critical thinking growth in courses can be effective through a variety of different means [14], [15], [19], [22]. These include having the students use AI, changing the teaching methodologies, incorporating critical thinking activities, and pretraining students for the course. There are benefits and drawbacks to all of these approaches such as the ease of implementation, how much extra time they would cost the students and professors, and how widely applicable these strategies are for different courses.

Table 1: Selected Works that Incorporate Methods to Promote Critical Thinking in Engineering Education

Source	Year	Intervention Method	Evaluation Method	Subject	Sample Size
Aini et al [23]	2025	T	S, R	Design Process	21
Cui [17]	2025	A	F	AI on Crit Thinking	25
Muter	2025	A	R	Comp Eng	
Cossu [19]	2024	C	S	Fluid Mech	174
Dhanasekaran [1]	2024	C	D	Machine Design	
Hendrick [20]	2024	T	R	Biomed	20
Pertiwi [18]	2024	C	I	Chemistry	144
Prayogi [21]	2024	T	I	Physics	83
Ruiz-Rojas et al [15]	2024	P	S	AI in higher education	121
Guerra et al. [16]	2024	A	S, F	Const Eng	18
Nopriyanti [24]	2020	T	D	CAD	15
Sharma [14]	2020	P	R	Eng. Drawing	120
Sirinterlikci	2019	C	D	Manuf. Eng	
Wahyadi [22]	2018	T	F	Physics	21
Jin [26]	2018	P	I	Elec Eng	36
Prayogi [7]	2018	T	F	Physics	21
Oulton [27]	2017	C	F	Civil Eng	70
Li [2]	2020	T	R	Manuf./CNC	63
Ahern [28]	2012	T	F	Varied	13
Masek [29]	2012	C	R	Elec Eng	53
Shoop [30]	2011	C	S	Multi	25
Lewis [31]	2009	P	R	Intro to Eng	90
Papadopoulos [32]	2006	T	D	Mechanics	105
Pariser [33]	2001	C	F	Physics	14
Intervention Methods: P = Pretrain, A = Incorporate AI, C = Incorporate Critical Thinking Skills, T = Change Teaching Methods **Evaluation Methods:** R = Repeated Measures, I = Independent Samples, S = Survey, F = Free response, D = Descriptive					

Due to the factors listed above, incorporating critical thinking activities into a previously designed course structure is the strategy selected for exploration through our proposed case study to promote critical thinking growth. Previous studies have concluded that this strategy is effective for promoting critical thinking growth, and it also appears to be the strategy that has the least detrimental effects. While pretraining students has been demonstrated to have benefits, this then requires time from both the students and the professor before the class starts, or, the reallocation of class time. This time may not be guaranteed from all participants, and this has to be taken into consideration when selecting a methodology. Changing the teaching methodology faces a different challenge where the course may have to be significantly modified to allow for this change. This could be a large change to the course structure, and making this change would be a much larger challenge because of that. Finally, AI is still an emerging and highly debated topic within the academic community, and the potential benefits and drawbacks of AI usage are still unknown.

The methodology of incorporating critical thinking activities into a course is selected as it demonstrates promise as a highly effective technique lacking major drawbacks. This does not cost the students nor professor extra time, it is relatively easy to incorporate, and it can be incorporated into a wide range of courses as all courses must have major topics and can therefore have activities based on these topics.

Limitations and Future Research

This research has several limitations that must be considered when evaluating the proposed course outline and recommendations. The first such limitation is the lack of previous implementation. This course has not yet been implemented and as such there is no data showing the effectiveness of this course outline. While the recommendations that have guided this course have been drawn from previous research that has been conducted, that does not necessarily mean that it will be as efficient in critical thinking development when implemented in the proposed course. The second such major limitation is the sample size even after this course has been implemented. The university where this will be implemented does not have an unlimited number of seats for this course, and as such only so many will be enrolled during a given semester. This will limit the number of students who are able to be studied, and this will provide a limited sample size and fewer results will be able to be derived because of this. Despite this, the sample size will not be limited to such an extreme that it will cause major issues, but this is still something to consider. To strengthen any findings from the future implementation of this course, other institutions should look to add similar courses to their programs to allow for a larger sample size that accounts for differing demographics. After conducting this study on a large enough sample of students that incorporate a diverse enough demographic, it is recommended that future work is done that examines these differences and attempts to create courses that are more specialized to fit the specific needs of individual institutions.

A recurring theme of the papers analyzed in this literature review was that a single isolated course that promotes critical thinking growth will not benefit students to the same degree as having multiple courses spread throughout their schooling. This study proposes the implementation of other such courses in parallel with the CAD course that was outlined above in order to promote greater critical thinking growth. This study recommends that other institutions who are looking to implement one such course examine the possibility of implementing this approach in multiple courses. This will allow for the studying of the effects of having courses spread through one's education compared to an isolated course and how this helps to develop the students’ critical thinking skills.

Conclusion

There are a number of different strategies that can be employed to promote critical thinking growth. There are also a range of methodologies that can be used to assess this growth with different methodologies focusing more on specific aspects of critical thinking. All of these methods, both to encourage and measure growth, have areas where they excel, and areas where they are not as proficient, and the correct approach must be chosen given the situation that it is going to be applied in. In general, this paper would recommend that critical thinking activities are employed to help promote critical thinking growth. With this in mind, the best recommendation is the one that fits best into the desired curriculum and most closely follows the current teaching philosophy.

Conflict of Interest

There are no conflicts of interest.

Data Availability Statement

No data, models, or code were generated or used for this article.

References

[1] P. Dhanasekaran, "The Crucial Role of Critical Thinking in an Integrated Approach to Machine Design Problems," in *Volume 7: Engineering Education*, Portland, Oregon, USA: American Society of Mechanical Engineers, Nov. 2024, p. V007T09A009. doi: 10.1115/IMECE2024-144064.

[2] Y. Li, X. Li, D. Zhu, and H. Guo, "Cultivation of the Students' Critical Thinking Ability in Numerical Control Machining Course Based on the Virtual Simulation System Teaching Method," *IEEE Access*, vol. 8, pp. 173584–173598, 2020, doi: 10.1109/ACCESS.2020.3025079.

[3] "Defining Critical Thinking," https://www.criticalthinking.org/pages/defining-critical-thinking/766 (accessed February 18, 2026).

[4] A. Ahern, C. Dominguez, C. McNally, J. J. O'Sullivan, and D. Pedrosa, "A literature review of critical thinking in engineering education," *Stud. High. Educ.*, vol. 44, no. 5, pp. 816–828, May 2019, doi: 10.1080/03075079.2019.1586325.

[5] M. Milligan, "Equipping Graduates to Build a Sustainable World," ABET. Accessed: Jan. 21, 2026. [Online]. Available: https://www.abet.org/equipping-graduates-to-build-a-sustainable-world/

[6] S. Jamali, Sehrash Arif, K. Hussain, N. Noonari, and A. R. Jamali, "A Survey on Critical Thinking Perception among Engineering Education Students," *J. Appl. Eng. Technol. JAET*, vol. 8, no. 1, pp. 52–59, Jun. 2024, doi: 10.55447/jaet.08.01.147.

[7] S. Prayogi, L. YUANITA, and Wasis, "Critical Inquiry Based Learning: A Model of Learning to Promote Critical Thinking Among Prospective Teachers of Physic," *J. Turk. Sci. Educ.*, vol. 15, no. 1, pp. 43–56, 2018.

[8] J. Silva, J. Edmond, and C. Jauregui, “Critical Thinking in the Classroom: Faculty Perspectives and Practices,” *J. Educ. Learn.*, vol. 14, no. 3, Jan. 2025, doi: 10.5539/jel.v14n3p1.
[9] D. Hitchcock, “Critical Thinking.” Accessed: Dec. 09, 2025. [Online]. Available: https://plato.stanford.edu/entries/critical-thinking/history.html#:~:text=John%20Dewey%20%281910:%2074%2C,thought%27%20or%20%27thinking%27
[10] J. Dewey, *How We Think*. D.C. Heath & Co., 1910.
[11] B. Gunnink and K. L. S. Bernhardt, “Writing, critical thinking, and engineering curricula,” in *32nd Annual Frontiers in Education*, Boston, MA, USA: IEEE, 2002, pp. F3H-2-F3H-7. doi: 10.1109/FIE.2002.1158211.
[12] D. A. Mindell, “BODIES, IDEAS, AND DYNAMICS: HISTORICAL PERSPECTIVES ON SYSTEMS THINKING IN ENGINEERING”.
[13] L. Lattuca, P. Terenzini, and F. Volkwein, “Engineering Change A Study of the Impact of EC2000,” ABET, 2006.
[14] G. V. S. S. Sharma, J. Raja Murugadoss, and V. Rambabu, “Fostering Higher Order Thinking Skills in Engineering Drawing,” *J. Eng. Educ. Transform.*, vol. 34, no. 1, p. 28, Jul. 2020, doi: 10.16920/jeet/2020/v34i1/148359.
[15] L. I. Ruiz-Rojas, L. Salvador-Ullauri, and P. Acosta-Vargas, “Collaborative Working and Critical Thinking: Adoption of Generative Artificial Intelligence Tools in Higher Education,” *Sustainability*, vol. 16, no. 13, p. 5367, Jun. 2024, doi: 10.3390/su16135367.
[16] D. Abril, M. Guerra, and S. Duran Ballen, “ChatGPT to Support Critical Thinking in Construction-Management Students,” in *2024 ASEE Annual Conference & Exposition Proceedings*, Portland, Oregon: ASEE Conferences, Jun. 2024, p. 48459. doi: 10.18260/1-2--48459.
[17] N. Cui and I. H. Yeter, “BOARD #125: Exploring the Role of Artificial Intelligence Tools in Enhancing Critical Thinking Skills in Engineering Prototype Design,” in *2025 ASEE Annual Conference & Exposition Proceedings*, Montreal, Quebec, Canada: ASEE Conferences, Jun. 2025, p. 55942. doi: 10.18260/1-2--55942.
[18] N. P. Pertiwi, S. Saputro, S. Yamtinah, and A. Kamari, “ENHANCING CRITICAL THINKING SKILLS THROUGH STEM PROBLEM-BASED CONTEXTUAL LEARNING: AN INTEGRATED E-MODULE EDUCATION WEBSITE WITH VIRTUAL EXPERIMENTS,” *J. Balt. Sci. Educ.*, vol. 23, no. 4, pp. 739–766, Aug. 2024, doi: 10.33225/jbse/24.23.739.
[19] R. Cossu, I. Awidi, and J. Nagy, “Critical thinking activities in fluid mechanics – A case study for enhanced student learning and performance,” *Educ. Chem. Eng.*, vol. 46, pp. 35–42, Jan. 2024, doi: 10.1016/j.ece.2023.10.004.
[20] C. Hendrick and K. Tilbury, “A Comprehensive Approach to Modeling Dynamic Biological Systems: Enhancing Critical Thinking and Mathematical Problem-Solving in Biomedical Engineering Education,” in *2024 ASEE Annual Conference & Exposition Proceedings*, Portland, Oregon: ASEE Conferences, Jun. 2024, p. 46430. doi: 10.18260/1-2--46430.
[21] S. Prayogi, M. R. Bilad, N. N. S. P. Verawati, and M. Asy’ari, “Inquiry vs. Inquiry-Creative: Emphasizing Critical Thinking Skills of Prospective STEM Teachers in the

Context of STEM Learning in Indonesia," *Educ. Sci.*, vol. 14, no. 6, p. 593, May 2024, doi: 10.3390/educsci14060593.
[22] Wahyudi, N. N. S. P Verawati, S. Ayub, and S. Prayogi, "Development of Inquiry-Creative-Process Learning Model to Promote Critical Thinking Ability of Physics Prospective Teachers," *J. Phys. Conf. Ser.*, vol. 1108, p. 012005, Nov. 2018, doi: 10.1088/1742-6596/1108/1/012005.
[23] M. Aini, M. Aini, A. M. Fitrianingrum, Z. Sandy, and J. A. Rungkat, "Engineering Design Process (EDP) Learning Model on Learning Outcomes, Critical Thinking and Communication Skills of Science Education Students".
[24] Nopriyanti, E. D. Kurniawan, and Darlius, "Developing Textbook Based on Higher Order Thinking Skills for Computer Aided Design Course:," in *Proceedings of the 4th Sriwijaya University Learning and Education International Conference (SULE-IC 2020)*, Palembang, Indonesia: Atlantis Press, 2020. doi: 10.2991/assehr.k.201230.188.
[25] R. S.-Y. Wong, "ChatGPT in Medical Education: Promoting Learning or Killing Critical Thinking?," *Educ. Med. J.*, vol. 16, no. 2, pp. 177–183, Jun. 2024, doi: 10.21315/eimj2024.16.2.13.
[26] Y.-F. Jin, "Training Students for Critical Thinking in an Electrical Engineering Core Course," in *2018 Gulf Southwest Section Conference Proceedings*, AT&T Executive Education and Conference Center, Austin, TX 78705: ASEE Conferences, Apr. 2019, p. 31554. doi: 10.18260/1-2-370.620-31554.
[27] R. Oulton, "Stimulating Critical Thinking in Engineering Students," in *2017 ASEE Annual Conference & Exposition Proceedings*, Columbus, Ohio: ASEE Conferences, Jun. 2017, p. 28849. doi: 10.18260/1-2--28849.
[28] A. Ahern, T. O'Connor, G. McRuairc, M. McNamara, and D. O'Donnell, "Critical thinking in the university curriculum – the impact on engineering education," *Eur. J. Eng. Educ.*, vol. 37, no. 2, pp. 125–132, May 2012, doi: 10.1080/03043797.2012.666516.
[29] A. Masek and S. Yamin, "The Impact of Instructional Methods on Critical Thinking: A Comparison of Problem-Based Learning and Conventional Approach in Engineering Education," *ISRN Educ.*, vol. 2012, pp. 1–6, Feb. 2012, doi: 10.5402/2012/759241.
[30] B. L. Shoop and E. K. Ressler, "Developing the Critical Thinking, Creativity and Innovation of Undergraduate Engineering Students".
[31] J. Lewis, J. Hieb, and D. Wheatley, "Explicit Teaching Of Critical Thinking In 'Introduction To Engineering,'" in *2009 Annual Conference & Exposition Proceedings*, Austin, Texas: ASEE Conferences, Jun. 2009, p. 14.611.1-14.611.21. doi: 10.18260/1-2--5513.
[32] C. Papadopoulos, A. Rahman, and J. Bostwick, "Assessing Critical Thinking In Mechanics In Engineering Education," in *2006 Annual Conference & Exposition Proceedings*, Chicago, Illinois: ASEE Conferences, Jun. 2006, p. 11.235.1-11.235.15. doi: 10.18260/1-2--1379.
[33] B. Pariser, "Teaching Critical Thinking," in *2001 Annual Conference Proceedings*, Albuquerque, New Mexico: ASEE Conferences, Jun. 2001, p. 6.938.1-6.938.11. doi: 10.18260/1-2--9858.