Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #47374

Research Brief: Fundamental Engineering Course Instructors' Beliefs on Test Question Design

Kai Jun Chew, Embry-Riddle Aeronautical University - Daytona Beach

Kai Jun "KJ" Chew is an assistant professor in the Engineering Fundamentals department at Embry-Riddle Aeronautical University. He is passionate about teaching and research, and he strives to produce knowledge that informs better teaching. His research intersects assessment and evaluation, motivation, and equity. His research goal is to promote engineering as a way to advance social justice causes.

Dr. Holly M Matusovich, Virginia Polytechnic Institute and State University

Dr. Holly Matusovich is the Associate Dean for Graduate and Professional Studies in the College of Engineering at Virginia Tech and a Professor in the Department of Engineering Education where she has also served in key leadership positions. Dr. Matusovich is recognized for her research and leadership related to graduate student mentoring and faculty development. She won the Hokie Supervisor Spotlight Award in 2014, received the College of Engineering Graduate Student Mentor Award in 2018, and was inducted into the Virginia Tech Academy of Faculty Leadership in 2020. Dr. Matusovich has been a PI/Co-PI on 19 funded research projects including the NSF CAREER Award, with her share of funding being nearly $3 million. She has co-authored 2 book chapters, 34 journal publications, and more than 80 conference papers. She is recognized for her research and teaching, including Dean's Awards for Outstanding New Faculty, Outstanding Teacher Award, and a Faculty Fellow. Dr. Matusovich has served the Educational Research and Methods (ERM) division of ASEE in many capacities over the past 10+ years including serving as Chair from 2017-2019. Dr. Matusovich is currently the Editor-in-Chief of the journal, Advances in Engineering Education and she serves on the ASEE committee for Scholarly Publications.

Research Brief: Fundamental Engineering Course Instructors' Beliefs on Test Question Design

Introduction

Heavy test usage in concept-heavy fundamental engineering courses (FECs) has been well documented in engineering education [1], [2], [3]. We argue that because of the benefits [4], [5], [6] and disadvantages [7], [8], [9], [10], [11], [12], [13], [14] shown in literature about testing, pragmatic and intentional use of testing should be considered instead of "defaulting" into heavy test usage in FECs [15]. At the same time, tests can play crucial role in assessing certain types of knowledge and promoting retention of foundational knowledge that helps with developing conceptual understanding [4], [6], [16]. With these considerations, we argue the need to be more intentional with test usage, which includes test design [15]. To begin to address this, we conducted empirical research to explore FEC instructors' beliefs on how they designed their test questions. Expanding literature on instructors' beliefs is crucial in promoting intentional test design as research has shown such beliefs can shape teaching behaviors in classrooms, and understanding test design beliefs can assist in improving test design. In this brief, we focus on test question design, and we answer the following question: *What are the beliefs of test question design of seven FEC instructors?*

Literature Review

Testing as educational assessments has been a highly debated topic that we argue should be treated with care, with the eventual decisions by instructors to use, design, implement, and improve testing in classroom should be done pragmatically and intentionally based on existing literature. Research has generally shown that tests can be featured heavily in engineering classrooms, with researchers describing this heavy use as "testing culture" [1], "gatekeepers" [17], [18], and implied to be the default assessment [2], [3]. There have been movements in the general education community to call for using various assessment approaches along with testing to assess students, which have shown to have positive impact on student outcomes in the classrooms [19], [20], [21], [22]. We propose that the engineering education community should consider using various approaches in addition to testing to have a more robust picture of outcomes of their students.

Such stance is based on extensive research on testing from multiple vantage points. Looking at the benefits, tests have shown to promote the testing effect [4], [5], [6], [16], assess procedural and algorithmic knowledge appropriately [7], and get students to prepare and study [8], [16]. From other vantage points, there have been calls for diversifying assessments from various perspectives, including classroom assessment to support student learning [23], [24], [25]. These tend to stem from studies that have shown disadvantages for students caused by poorly designed and administered tests, such as employing study approaches that tend to focus on recalling instead of understanding [7], [9], [26], [27], [28], focusing on fear of failure due to worrying about the outcome instead of the preparation [10], [11], [29], and test anxiety that can

lead to avoidance achievement and underperformance [12], [13], [14], [30], [31], [32], [33], [34]. These vantage points all contribute substantial perspectives into this debate, and subsequently our call for a more intentional and pragmatic approach in testing in engineering classrooms.

Intentional and pragmatic testing has been explored in education with promising outcomes, such as frequent testing [35], [36], [37], [38] and two-stage exams [39], [40]. Another perspective of intentional and pragmatic testing is test design research, specifically on test question design, which is abundant in engineering education. However, much research focuses on procedures of what kind of new design is being done and lacks explanations of the beliefs behind why such new design is used and created [41]. There have been documentations of different question types and evaluations of the different question types. Specifically, the question types focus a lot on multiple-choice, constructed-response, and conceptual-based questions [42], [43], [44], [45]. Engineering exams tend to use both constructed-response, or workout questions, and multiple-choice questions [46], and research in higher education tends to compare both of these types. Workout questions are questions where students, given a context, have to construct their solutions based on engineering concepts [47], [48]. Some argue that constructed response can assess students thinking skills as compared to multiple-choice questions, specifically that multiple-choice questions can elicit memorization among students in their study habits and preparations for the exams [31], [49]. Research has also shown that students tend to prefer multiple-choice questions due to the ease of "guessing" [50]. Ultimately, there are continuous debates on both types of test question. Conceptual questions, which can be designed in both constructed response or multiple choice, are considered a way to address students' rote memorization in testing [51], [52]. Research on conceptual questions is scarce generally, but there has been documented attempts to incorporate these types of questions in engineering, such as concept inventories [53], [54], [55], [56] and concept explanations [52]. In addition, due to the Covid-19 pandemic, test design research has also documented the changes made to adapt to virtual learning [57], [58], [59]. All in all, documented research shows wide amount of the new design and innovations. However, a comprehensive study on instructors' beliefs explaining why these designs and innovations in tests does not appear to be widely studied, and our study will contribute to this literature domain.

Methods

We used secondary data analysis on an existing multi-case data set for this study (Figure 1), as approved by the Institutional Review Board (IRB) of the authors' institution. The original multi-case study involved seven FEC instructor participants (or cases) engaging in the research to explore their test usage beliefs and behaviors. The data set consists of two interviews, course syllabi, and tests used in the courses from each instructor, which aligns with Yin's case study research methodology on answering the research questions with multiple sources and types of data [60], [61]. The interviews, each happening a few months apart to allow us to analyze the document data, were collected to understand the participants' thoughts on their test usage, while also expressing their behaviors on how they used tests in their FECs [62], [63]. The document

data of course syllabi and tests used provided insights on how the participants used, designed, and administered their tests, giving us views of the unspoken behaviors the participants demonstrated [64], [65].

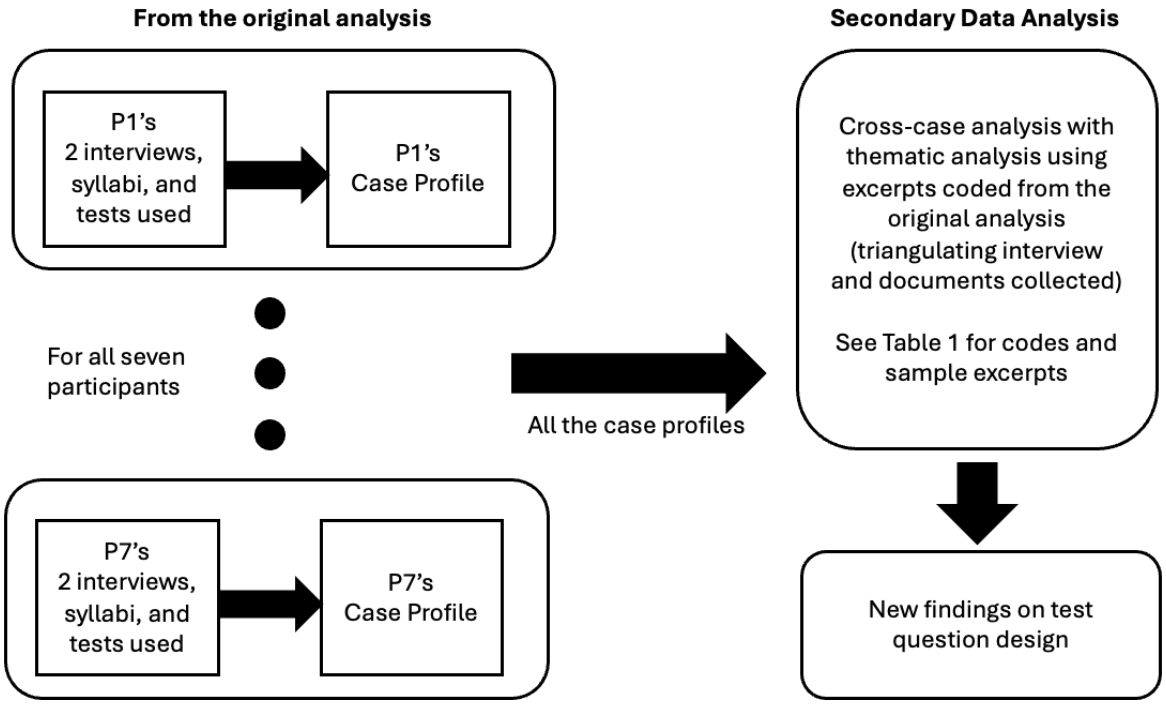

Figure 1: The secondary data analysis process in relation to the original study.

Secondary data analysis can serve many purposes in education research, with some including answering different research questions with existing data set, having new researchers analyzing the data for potentially new insights, and having the same researchers analyzing the data they collected after a certain period of time [66], [67]. Our interpretations of secondary data analysis aligned with the third reason, considering we both have transformed positionalities since the data were collected in the year 2021, which led to different interpretations and emergence of findings on test design. Illustrated in Figure 1, our secondary data analysis involved a new process of cross-case analysis that used the codes and case profiles from the original analysis as the foundation for us to re-analyze the data set.

The analysis process of the secondary data analysis involved taking the excerpts and codes from the original analysis (Figure 1 and Table 1). We collected all excerpts that were coded with relevant to each other, such as test definition and implementation, connections with learning, problem-based questions, test format, and others from both interview and test documents. We conducted thematic analysis (across seven cases with cross-case) based on these codes and excerpts, leading to test question design being the overarching theme to describe these seven instructor participants' beliefs and behaviors on test question design.

Table 1: The codes and some example excerpts that lead to emergence of "Test Question Design" as the code for this manuscript presented in the Findings section.

	Interview Transcripts	Test/Exam Documents
Original Analysis Codes	• Test definition or implementation (format/type and procedure) • Test connections with learning outcomes	• Problem-based questions or workout problems • Test format/type • Test procedure • Conceptual-based questions
Example Interview Excerpts of Document Descriptions	P2: "…I try to do a lot of short quick like concept kinds of things, … I can test if they know a concept; Those tend to be a lot more on the concepts related to the course … to get around the cheating…"	P2: Used conceptual questions that had students show understanding of relationships of variables within a thermodynamic equation; if a variable increases, how would other variables change.
	P5: "… statics were concerned about the fundamental application of equilibrium and so we're really investigating and making sure that the students were posing the question, do you understand how to visualize a force, can you find in components in any coordinate axes, and then how can you properly attribute the forces in and all the spaces. Because of these focuses for the most part statics exams all have workout problems…"	P5: Used all workout problems in their exams, with no conceptual questions.

Findings

We found two groups of cases from the seven participants on how they designed their test questions, as presented in Figure 2. Two participants, P3 and P5, only used workout questions while the rest complemented the workout questions with conceptual questions (Figure 2).

For both P3 and P5, they expressed their goal to assess student problem-solving processes. P3 said that these workout problems got students to apply equations or knowledge the students have learned to solve a problem and obtain the final answers. P3 emphasized that students should be able to solve problems, saying that: "That [actually solving problems] is fairly useful for engineers … [to] prove … that it's [a bridge designed] not going to fall down the first time someone steps on it, and that they can do that accurately…" P3 made a strong emphasis on the need to assess their students' problem solving process since it was a crucial skill for an engineer. P5 also had similar belief in justifying their use of only workout questions, but they argued from the perspective that students needed to understand the concept well to be able to find information for use when they became engineers in the future:

"Because it's a very problem solving based field … because in these classes we're teaching them very specific concepts that we want them to know coming out, or at least be able to understand and talk about intelligently; you might not ever remember specifically how to do certain kinds of problems right, but you would know enough that if you picked up a textbook you could refresh yourself on how to do it…."

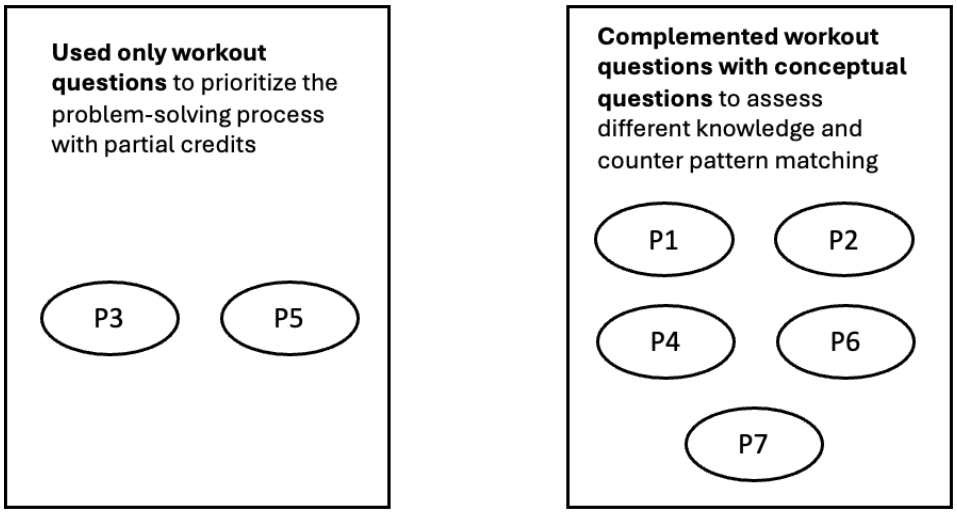

Figure 2: The two groups emerged on beliefs and behaviors of test question design.

Both P3 and P5 also discussed the workout questions that helped with providing partial credits for the students, with both arguing that conceptual questions tend to be restrictive in terms of grading, with the idea that partial credits emphasize the importance of the problem-solving process. P5 described this "heavy emphasis on the process," arguing that "if [the students] followed all the steps correctly and showed that they knew what to do, P5 would take a point off just that they notice that there was something wrong, but not to really punish that kind of a mistake." P3 also explained similarly, explaining that they "want[ed] to be able to highlight those mistakes [that students made] because in practice, if a student tells [them] a bridge could hold 50 cars, but it could actually only hold five cars, that's a real problem when [one] opens that bridge and put 50 cars on it. It's just a little mistake … but it has a real impact." Overall, both P3 and P5 expressed strong opinions about using only the workout questions because of their focus to assess their students' problem-solving skills.

As for the remaining participants, they all explained the need to complement workout questions with conceptual questions for reasons that involve needing to assess different knowledge and to counter student pattern matching when solving workout questions. P1 and P4 both valued concepts and students understanding of them. From P4, they said that:

"[the students] understand[ing] the concepts does not mean they understand how to solve it, because there are two different things [understanding and solving]."

P1 shared similar beliefs, expressing that he also focused on whether "students really understand the basic concepts." Other participants discussed the need to counter pattern matching among their students in the workout questions. P3 and P7 both raised this concern, with P7 explaining that:

> The kind of [test questions] … is not the best way to do that because students really perceive it as how well they can memorize a homework problem, as opposed to really understanding them. That's why I try to incorporate more concept questions.

P7 argued that having conceptual questions could assess their students conceptual understanding since P7 implied that conceptual questions may not be easier to pattern match. P7 used multiple-choice format to identify misconceptions among their students. P3 also explained similarly, arguing that concept question "is a little more challenging to get [students] to [work on] … especially to get around the cheating." P3 mentioned cheating as one of the reasons to use conceptual questions, which we interpreted as similar to pattern matching. All participants in this group had implied or mentioned the need to assess their students problem-solving skills with the use of workout questions, like the two participants who solely used workout questions. The differences were that the participants in the second grouping wanted to ensure a different way to assess student and address pattern matching or cheating among their students.

Discussions and Implications

Test question design research has focused a lot more on implementing new design without a comprehensive understanding of the beliefs that shape these designs. Our research has contributed to this domain by showing the different beliefs that our participants explained in their use of workout questions and conceptual questions. Our findings have shown consistent arguments about the use of workout questions to assess problem-solving problems [31], [48], [49]. In terms of findings for complementing concept questions with workout questions, our findings have added to literature since there has not been much literature on the topic as far as we are concerned. Some participants used multiple-choice concept inventories as their conceptual questions to complement workout questions [53], [55], [56]. In addition, we also found the nuanced belief systems that our participants showed in test question design, such as the need to assess different knowledge [7], [68] and the need to address pattern matching [26], [27], [69], [70]. Our findings also align with some recommended effective practices, such as Suskie's [71] where assessments should focus on thinking and performance skills (participants' want to improve students' problem-solving skills and assess different knowledge with different test design). Overall, our studies have contributed to a more detailed exploration of instructors' beliefs in test question design.

References

[1] O. Rompelman, “Assessment of student learning: Evolution of objectives in engineering education and the consequences for assessment,” *European Journal of Engineering Education*, vol. 25, no. 4, pp. 339–350, 2000, doi: 10.1080/03043790050200386.

[2] S. Sheppard, K. Macatangay, A. Colby, and W. M. Sullivan, *Educating engineers: Designing for the future of the field*. San Francisco, CA: Jossey-Bass, 2009.

[3] S. M. Lord and J. C. Chen, “Curriculum design in the middle years,” in *Cambridge handbook of engineering educatinon research*, A. Johri and B. M. Moskal, Eds., New York, NY: Cambridge University Press, 2014, ch. 10, pp. 181–199.

[4] M. A. McDaniel, J. L. Anderson, M. H. Derbish, and N. Morrisette, “Testing the testing effect in the classroom,” *European Journal of Cognitive Psychology*, vol. 19, no. 4–5, pp. 494–513, 2007, doi: 10.1080/09541440701326154.

[5] C. Yang, R. Potts, and D. R. Shanks, “Enhancing learning and retrieval of new information: a review of the forward testing effect,” *Science of Learning*, vol. 3, no. 1, Dec. 2018, doi: 10.1038/s41539-018-0024-y.

[6] H. Choi and H. S. Lee, “Knowing Is Not Half the Battle: the Role of Actual Test Experience in the Forward Testing Effect,” *Educ Psychol Rev*, vol. 32, no. 3, pp. 765–789, Sep. 2020, doi: 10.1007/s10648-020-09518-0.

[7] J. Case and D. Marshall, “Between deep and surface: Procedural approaches to learning in engineering education contexts,” *Studies in Higher Education*, vol. 29, no. 5, pp. 605–615, 2004, doi: 10.1080/0307507042000261571.

[8] S. Van Etten, G. Freebern, and M. Pressley, “College students’ beliefs about exam preparation,” *Contemp Educ Psychol*, vol. 22, no. 2, pp. 192–212, 1997, doi: 10.1006/ceps.1997.0933.

[9] K. Scouller, “The influence of assessment method on students’ learning approaches: Multiple choice question examination versus assignment essay,” *High Educ (Dordr)*, vol. 35, no. 4, pp. 453–472, 1998, doi: 10.1023/A:1003196224280.

[10] C. M. Tan, “An evaluation of the use of continuous assessment in the teaching of physiology,” *High Educ (Dordr)*, vol. 23, no. 3, pp. 255–272, 1992, doi: 10.1007/BF00145016.

[11] D. Cock and H. Halvari, “Relations among achievement motives, autonomy, performance in mathematics, and satisfaction of pupils in elementary school,” *Psychol Rep*, vol. 84, pp. 983–997, 1999.

[12] C. P. Denwigwe and S. C. Jacks, “Academic test anxiety and mathematics performance of senior secondary school students in Model Secondary School Maitama, Abuja, Nigeria,” *European Journal of Scientific Research*, vol. 156, no. 4, pp. 429–438, 2020, [Online]. Available: http://www.europeanjournalofscientificresearch.com

[13] L. D. Wahyuni, R. Citraini, B. A. Hutomo, and G. G. F. Rakhman, “Anxiety and test form: The differences of test anxiety levels in terms of test form,” *Jurnal Pengukuran Psikologi dan Pendidikan Indonesia*, vol. 10, no. 2, pp. 184–192, 2021, doi: 10.15408/jp3i.v10i2.17974.

[14] J. C. Major, M. Scheidt, A. Godwin, E. J. Berger, and J. Chen, “Effect of test anxiety on first-year students’ STEM Success,” in *Proceedings of the American Society for Engineering Education Annual Conference & Exposition (Virtual)*, 2020.

[15] K. J. Chew and H. M. Matusovich, “Exploring fundamental engineering course instructors’ test usage beliefs and behaviors: A multicase study,” *Journal of Engineering Education*, vol. 113, no. 4, pp. 1146–1176, Aug. 2024, doi: 10.1002/jee.20614.

[16] J. L. Jensen, M. A. McDaniel, S. M. Woodard, and T. A. Kummer, “Teaching to the test…or testing to teach: Exams requiring higher order thinking skills encourage greater conceptual understanding,” *Educ Psychol Rev*, vol. 26, no. 2, pp. 307–329, 2014, doi: 10.1007/s10648-013-9248-9.

[17] P. Nagy, “The Three Roles of Assessment : Gatekeeping, Accountability , and Instructional Diagnosis,” *Canadian Journal of Education*, vol. 25, no. 4, pp. 262–279, 2000.

[18] J. Sabrowsky, “Gatekeeping through assessment: Understanding a systematic problem in the STEM degree pipeline,” 2023.

[19] B. K. Sato, C. F. C. Hill, and S. M. Lo, “Testing the test: Are exams measuring understanding?,” *Biochemistry and Molecular Biology Education*, vol. 47, no. 3, pp. 296–302, May 2019, doi: 10.1002/bmb.21231.

[20] J. K. Seale, J. Chapman, and C. Davey, “The influence of assessments on students’ motivation to learn in a therapy degree course,” *Med Educ*, vol. 34, no. 8, pp. 614–621, 2000, doi: 10.1046/j.1365-2923.2000.00528.x.

[21] E. Cifrian, A. Andrés, B. Galán, and J. R. Viguri, “Integration of different assessment approaches: application to a project-based learning engineering course,” *Education*

for Chemical Engineers, vol. 31, pp. 62–75, Apr. 2020, doi: 10.1016/j.ece.2020.04.006.

[22] M. C. Schneider, K. L. Egan, and M. W. Julian, "Classroom assessment in the context of high-stakes testing," in *Sage handbook of research on classroom assessment*, 2013, pp. 55–70.

[23] J. H. McMillan, "Important contexts for research on classroom assessment," in *Sage handbook of research on classroom assessment*, 2013, pp. 3–16.

[24] G. Gibbs and C. Simpson, "Does your assessment support your students' learning?," *Journal of Teaching and Learning in Higher Education*, vol. 1, no. 1, pp. 1–30, 2004.

[25] L. A. Shepard, "The role of assessment in a learning culture," *Educational Researcher*, vol. 29, no. 7, pp. 4–14, 2000.

[26] F. Marton and R. Säljö, "On qualitative differences in learning: I. Outcome and process*," *British Journal of Educational Psychology*, vol. 46, pp. 4–11, 1976, doi: 10.1111/j.2044-8279.1976.tb02980.x.

[27] F. Marton and R. Säljö, "On qualitative differences in learning: II. Outcome as a function of learner's conception of the task," *British Journal of Educational Psychology*, vol. 46, pp. 115–127, 1976.

[28] G. Gibbs, L. Lucas, and J. Spouse, "The effects of class size and form of assessment on nursing students' performance, approaches to study and course perceptions," *Nurse Educ Today*, vol. 17, no. 4, pp. 311–318, 1997, doi: 10.1016/S0260-6917(97)80062-7.

[29] S. Berger and A. M. Freund, "Fear of failure, disorganization, and subjective well-being in the context of preparing for an exam," *Swiss Journal of Psychology*, vol. 71, no. 2, pp. 83–91, Apr. 2012, doi: 10.1024/1421-0185/a000074.

[30] D. Parsons, "Is there an alternative to exams? - Examination stress in engineering courses," *International Journal of Engineering Education*, vol. 24, no. 6, pp. 1111–1118, 2008.

[31] K. F. Stanger-Hall, "Multiple-choice exams: An obstacle for higher-level thinking in introductory science classes," *CBE Life Sci Educ*, vol. 11, no. 3, pp. 294–306, 2012, doi: 10.1187/cbe.11-11-0100.

[32] A. J. Elliot and H. A. McGregor, "Test anxiety and the hierarchical model of approach and avoidance achievement motivation," 1999. doi: 10.1037/0022-3514.76.4.628.

[33] M. V. Covington and C. L. Omelich, "'I Knew It Cold Before the Exam': A Test of the Anxiety-Blockage Hypothesis," *J Educ Psychol*, vol. 79, no. 4, pp. 393–400, 1987, doi: 10.1037/0022-0663.79.4.393.

[34] R. E. Culler and C. J. Holahan, "Test anxiety and academic performance: The effects of study-related behaviors," *J Educ Psychol*, vol. 72, no. 1, pp. 16–20, 1980, doi: 10.1037/0022-0663.72.1.16.

[35] R. L. Bangert-Drowns, J. A. Kulik, and C.-L. C. Kulik, "Effects of frequent classroom testing," *Journal of Educational Research*, vol. 85, no. 2, pp. 89–99, 1991, doi: 10.1080/00220671.1991.10702818.

[36] B. E. Vaessen, A. van den Beemt, G. van de Watering, L. W. van Meeuwen, L. Lemmens, and P. den Brok, "Students' perception of frequent assessments and its relation to motivation and grades in a statistics course: a pilot study," *Assess Eval High Educ*, vol. 42, no. 6, pp. 872–886, 2017, doi: 10.1080/02602938.2016.1204532.

[37] D. H. Smith, C. Emeka, M. Fowler, M. West, and C. Zilles, "Investigating the Effects of Testing frequency on programming performance and students' behavior," in *SIGCSE 2023 - Proceedings of the 54th ACM Technical Symposium on Computer Science Education*, Association for Computing Machinery, Inc, Mar. 2023, pp. 757–763. doi: 10.1145/3545945.3569821.

[38] J. W. Morphew, M. Silva, G. Herman, and M. West, "Frequent mastery testing with second-chance exams leads to enhanced student learning in undergraduate engineering," *Appl Cogn Psychol*, vol. 34, no. 1, pp. 168–181, 2020, doi: 10.1002/acp.3605.

[39] M. Fengler and P. M. Ostafichuk, "Successes With two-Stage Exams in Mechanical Engineering," in *Proceedings of the Canadian Engineering Education Association Hamilton Ontario*, 2015, pp. 1–5. doi: 10.24908/pceea.v0i0.5744.

[40] M. D. Koretsky, C. J. McColley, J. L. Gugel, and T. W. Ekstedt, "Aligning classroom assessment with engineering practice: A design-based research study of a two-stage exam with authentic assessment," *Journal of Engineering Education*, vol. 111, no. 1, pp. 185–213, Jan. 2022, doi: 10.1002/jee.20436.

[41] J. G. Halls, C. Tomás, J. S. Owen, and K. Hawwash, "Mapping out the landscape of literature on assessment in engineering education," *European Journal of Engineering Education*, vol. 47, no. 3, pp. 373–393, 2022, doi: 10.1080/03043797.2021.2009775.

[42] N. Chan and P. E. Kennedy, "Are multiple-choice exams easier for economics students? A comparison of multiple-choice and 'equivalent' constructed-response

exam questions," *South Econ J*, vol. 68, no. 4, pp. 957–971, 2002, doi: 10.2307/1061503.

[43] M. G. Simkin, W. E. Keuchler, A. Savage, and D. Stiver, "Why Use Multiple-Choice Questions on Accounting Certification Examinations?," *Global Perspectives on Accounting Education*, vol. 8, no. Mc, pp. 27–46, 2011.

[44] M. L. Grunert, J. R. Raker, K. L. Murphy, and T. A. Holme, "Polytomous versus dichotomous scoring on multiple-choice examinations: Development of a rubric for rating partial credit," *J Chem Educ*, vol. 90, no. 10, pp. 1310–1315, 2013, doi: 10.1021/ed400247d.

[45] A. D. Slepkov and A. T. K. Godfrey, "Partial Credit in Answer-Until-Correct Multiple-Choice Tests Deployed in a Classroom Setting," *Applied Measurement in Education*, vol. 32, no. 2, pp. 138–150, 2019, doi: 10.1080/08957347.2019.1577249.

[46] P. Photopoulos, C. Tsonos, I. Stavrakas, and D. Triantis, "Preference for multiple choice and constructed response exams for engineering students with and without learning difficulties," in *Proceedings of the 13th International Conference on Computer Supported Education*, 2021, pp. 220–231. doi: 10.5220/0010462502200231.

[47] P. Laskowski, S. Karayev, and M. A. Hearst, "How do professors format exams? An analysis of question variety at scale," in *Proceedings of the 5th Annual ACM Conference on Learning at Scale*, Association for Computing Machinery, Inc, Jun. 2018. doi: 10.1145/3231644.3231667.

[48] D. W. Petr, "Experience with a multiple-choice audience response system in an engineering classroom," in *Proceedings - Frontiers in Education Conference (FIE)*, 2005, pp. 1–6. doi: 10.1109/fie.2005.1612282.

[49] M. E. Martinez, "Cognition and the question of test item format," *Educ Psychol*, vol. 34, no. 4, pp. 207–218, 1999, doi: 10.1207/s15326985ep3404_2.

[50] M. Zeidner, "Essay versus Multiple-Choice Type Classroom Exams: The Student's Perspective," *Journal of Educational Research*, vol. 80, no. 6, pp. 352–358, 1987, doi: 10.1080/00220671.1987.10885782.

[51] K. L. Kitto, "Perspectives from the classroom -Developing effective concept questions and collaborative learning for an introductory materials engineering course," in *Proceedings of the Frontiers in Education Conference*, 2006.

[52] Eric. Mazur, *Peer instruction: a user's manual*. Pearson, 2014.

[53] A. H. Espera and N. P. Pitterson, “Statistical analysis of an adaptive concept inventory in introductory electric circuits for students and instructors,” in *Proceedings of American Society for Engineering Education (ASEE)*, Minneapolis, MN, 2022. [Online]. Available: www.slayte.com

[54] C. M. Firetto, P. N. Van Meter, A. M. Kottmeyer, S. R. Turns, and T. A. Litzinger, “An extension of the Thermodynamics Conceptual Reasoning Inventory (TCRI): measuring undergraduate students’ understanding of introductory thermodynamics concepts,” *Int J Sci Educ*, vol. 43, no. 15, pp. 2555–2576, 2021, doi: 10.1080/09500693.2021.1975847.

[55] D. Hestenes, M. Wells, and G. Swackhamer, “Force concept inventory,” *Phys Teach*, vol. 30, pp. 141–158, 1992.

[56] P. S. Steif and J. A. Dantzler, “A statics concept inventory: Development and psychometric analysis,” *Journal of Engineering Education*, vol. 94, no. 4, pp. 363–371, 2005, doi: 10.1002/j.2168-9830.2005.tb00864.x.

[57] N. A. Jankowski, “Assessment during a Crisis: Responding to a Global Pandemic,” 2020.

[58] S. Asgari, J. Trajkovic, M. Rahmani, W. Zhang, R. C. Lo, and A. Sciortino, “An observational study of engineering online education during the COVID-19 pandemic,” *PLoS One*, vol. 16, no. 4 April, pp. 1–17, 2021, doi: 10.1371/journal.pone.0250041.

[59] A. R. Yadav, K. N. Talati, and R. K. Gurjwar, “Leveraging Technology Platform for Timely Conducting Online University-Level Examinations Amid COVID-19 Pandemic: An Experiential Narrative by Engineering Faculty From Western India,” in *Advances in Social Science, Education and Humanities Research*, 2020, pp. 533–538. doi: 10.2991/assehr.k.201105.095.

[60] R. K. Yin, *Case study research and applications: Design and methods*, 6th ed. Thousand Oaks, California: Sage Publications, 2018.

[61] B. Yazan, “Three approaches to case study methods in education: Yin, Merriam, and Stake,” *The Qualitative Report*, vol. 20, no. 2, pp. 134–152, 2015.

[62] W. C. Adams, “Conducting semi-structured interviews,” in *Handbook of practical program evaluation*, 4th ed., John Wiley & Sons, 2015, pp. 492–505.

[63] S. Kvale, “Ten standard objections to qualitative research interviews,” *Journal of Phenomelogical Psychology*, vol. 25, no. 2, pp. 147–173, 1994.

[64] G. A. Bowen, “Document analysis as a qualitative research method,” *Qualitative Research Journal*, vol. 9, no. 2, pp. 27–40, 2009, doi: 10.3316/QRJ0902027.

[65] J. A. Hatch, *Doing qualitative research in education settings*. Albany, New York: State University of New York Press, 2002.

[66] E. Smith, “Pitfalls and promises: The use of secondary data analysis in educational research,” *British Journal of Educational Studies*, vol. 56, no. 3, pp. 323–339, Sep. 2008, doi: 10.1111/j.1467-8527.2008.00405.x.

[67] M. C. Paretti *et al.*, “Building capacity in engineering education research through collaborative secondary data analysis,” *Australasian Journal of Engineering Education*, vol. 28, no. 1, pp. 8–16, 2023, doi: 10.1080/22054952.2023.2214462.

[68] D. Timmermann and C. H. Kautz, “Multiple choice questions that test conceptual understanding: A proposal for qualitative two-tier exam questions,” in *ASEE Annual Conference and Exposition, Conference Proceedings*, 2015. doi: 10.18260/p.24516.

[69] R. Kelley and B. Dooley, “The technology of cheating,” in *2014 IEEE International Symposium on Ethics in Science, Technology and Engineering, ETHICS 2014*, IEEE, 2014, pp. 14–17. doi: 10.1109/ETHICS.2014.6893442.

[70] D. D. Carpenter, T. S. Harding, C. J. Finelli, S. M. Montgomery, and H. J. Passow, “Engineering students’ perceptions of and attitudes towards cheating,” *Journal of Engineering Education*, vol. 95, no. 3, pp. 181–194, 2006, doi: 10.1002/j.2168-9830.2006.tb00891.x.

[71] L. Suskie, *Assessing student learning: A common sense guide*. Jossey-Bass, 2018.