Designing Authentic Assessments for Learning

May 30, 2022

Diana Skrzydlo

UNIVERSITY OF WATERLOO | FACULTY OF MATHEMATICS

Enhancing Assessment Practices

- Scoping review of literature on assessment in STEM
- Results in 5 categories:
  1. Quizzes/Tests
  2. Assignments/Projects
  3. In-Class Assessments
  4. Self-Learning/Mastery Grading
  5. Communication/Other

1. Quizzes/Tests

- No performance gap in computer vs paper delivery
  - Some benefits of computer (multiple attempts)
- Questions
  - Student-written questions
  - Longer sentences hinder understanding
- Preparation
  - Practice tests/questions
  - Reference sheet vs open book

2. Assignments/Projects

- Topic choices
  - Student interests
  - Agency increases engagement
- Scaffolding
  - Provide support and feedback
  - Several short projects more effective than one long one
  - Exemplars

3. In-Class Assessments

- In-class multiple choice quizzes
  - No difference if images are present
- Hands-on activities
  - Labs, worksheets, scenario discussions
- Rubrics
  - Students clarify learning goals

4. Self-Learning/Mastery Grading

- Optional test re-takes
  - Various grading options, less inflationary pressure
  - Grades improved, mixed effect on anxiety, increased time
- Mastery grading
  - Multiple attempts to achieve mastery of learning outcomes
  - Reduced anxiety, requires clear objectives
- Self-assessment
  - Correlation with instructor grades mixed
  - Guidance and feedback essential

5. Communication/Other

- Oral exams
  - Students can better articulate understanding
- Writing exercises
  - Short in-class activities improved exam performance
- Group video assignments
  - Developed effective digital communication skills

Key Takeaways

- Research supports the use of authentic assessments to enhance student learning in statistics
- Perceived efficacy and quality feedback are essential
- Try it and encourage your colleagues to do it too!

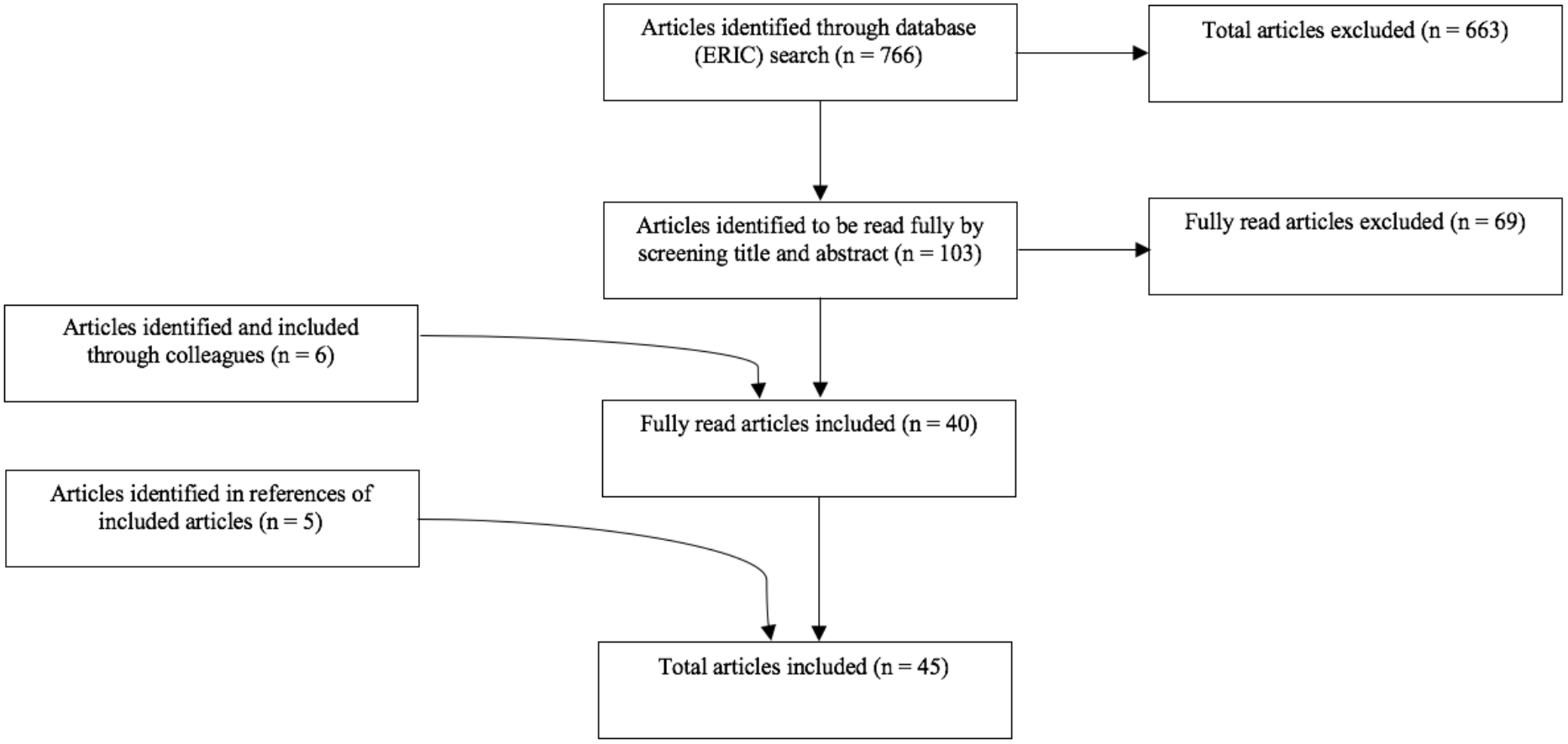
dkchisho@uwaterloo.ca
@ActSciProf on Twitter
uwaterloo.ca/scholar/dkchisho/blog

Appendix – More about scoping review process and references

Scoping Review Process

- Research question:
  - What is known from existing literature about practices for educators to assess students in undergraduate STEM education?
- Search strategy and terms:
  - ERIC database, “Assessment” AND “STEM or Math”
  - Peer reviewed, higher ed, English only
- Screening process:
  - 766 abstracts read -> 103 papers fully read -> 45 included

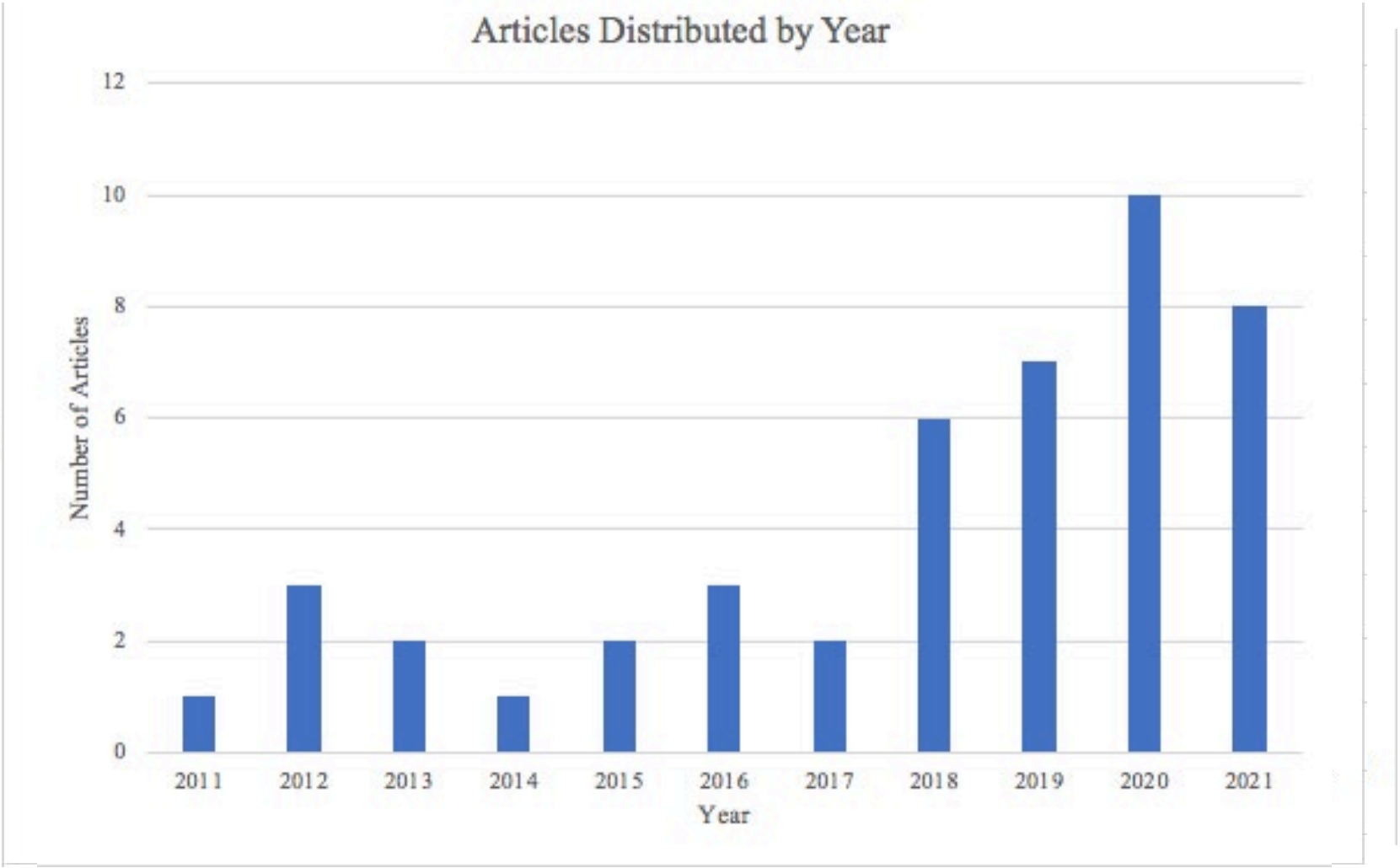
Screening


Articles identified through database (ERIC) search (n = 766)
Total articles excluded (n = 663)
Articles identified to be read fully by screening title and abstract (n = 103)
Fully read articles excluded (n = 69)
Articles identified and included through colleagues (n = 6)
Fully read articles included (n = 40)
Articles identified in references of included articles (n = 5)
Total articles included (n = 45)

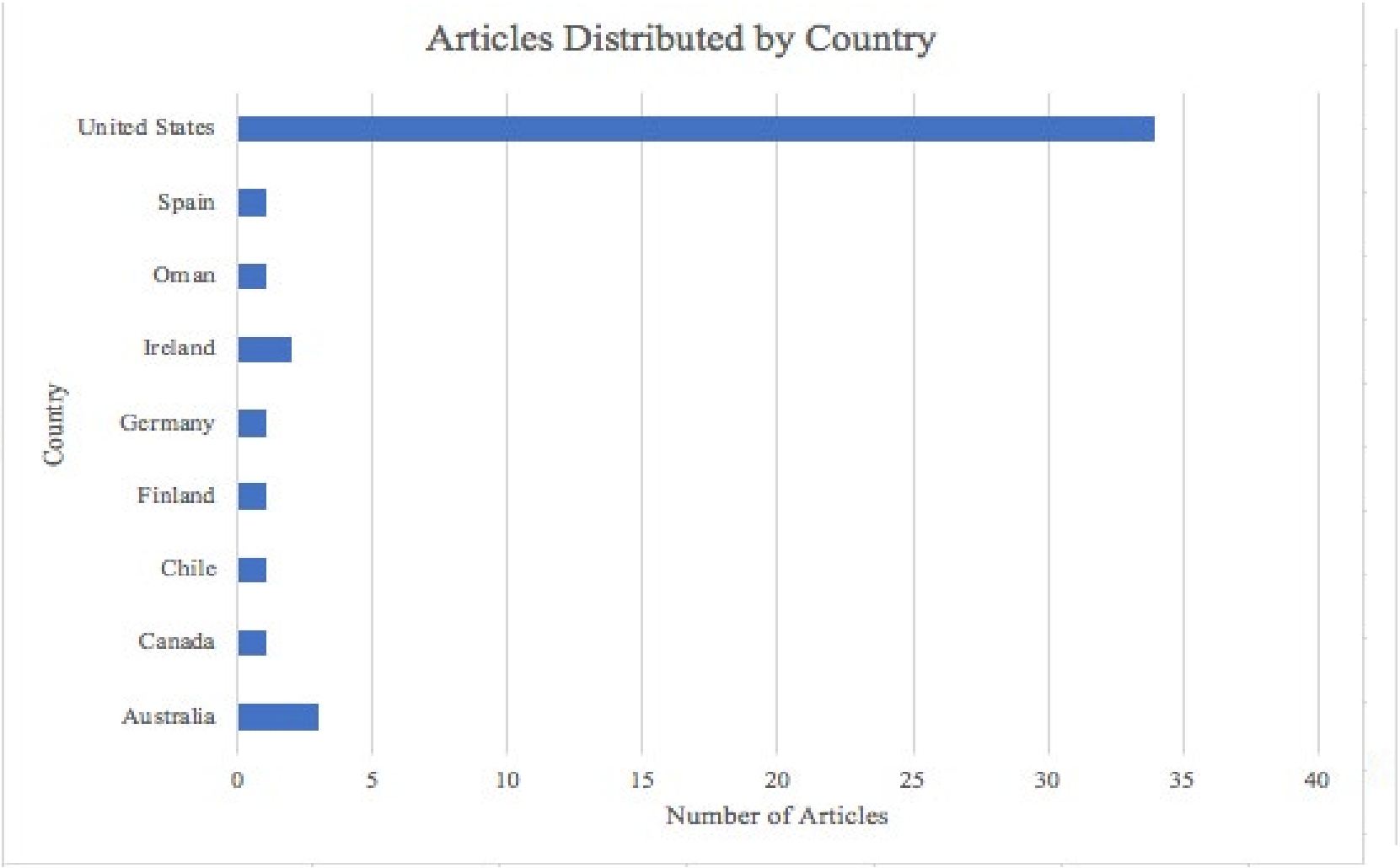
Data Charted

- Article info: title, author(s), year of publication, journal of publication, source
- Instructional context: subject(s) or course, class size, number respondents, institution(s), country, course delivery modality
- Study details: purpose of the study, type(s) of assessment used, the goal behind the assessment(s), results
- Potential application: extra resources, best practices, limitations, instruments used

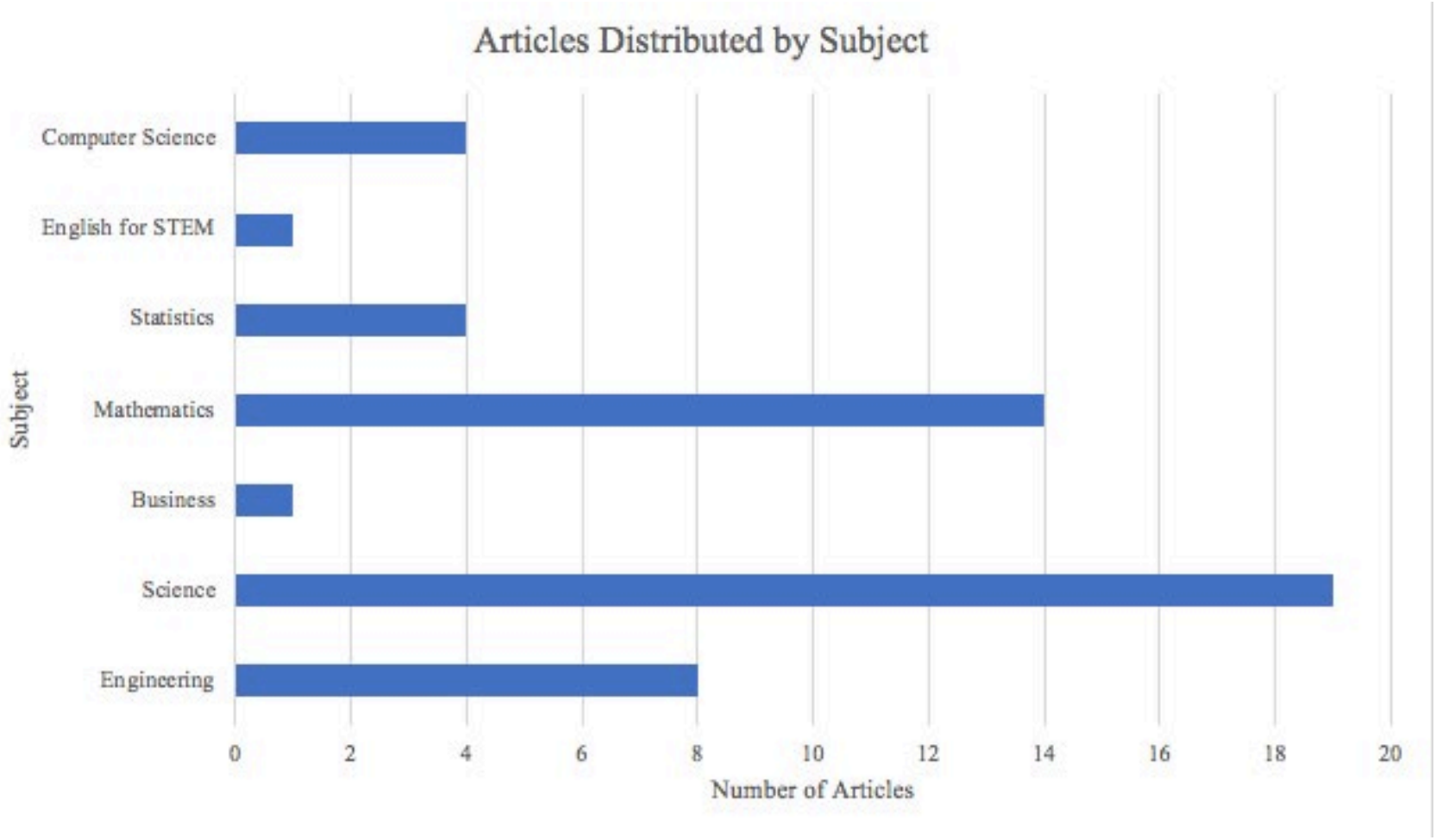
Paper Demographics



Paper Demographics



Paper Demographics



Paper Demographics

Funding

- Faculty of Math Strategic Plan initiative
- Gov't of Canada Student Work Placement Program

References – Quizzes/Tests

Block, R. M. (2012). A Discussion of the Effect of Open-book and Closed-book Exams on Student Achievement in an Introductory Statistics Course. *PRIMUS*, *22*(3), 228–238. https://doi.org/10.1080/10511970.2011.565402

Camfield, E. K., Schiller, N. R., & Land, K. M. (2021). Nipped in the bud: Covid-19 reveals the malleability of stem student self-efficacy. *CBE Life Sciences Education*, *20*(2), 1–18. https://doi.org/10.1187/cbe.20-09-0206

Crowther, G., Wiggins, B., & Jenkins, L. (2020). Testing in the Age of Active Learning: Test Question Templates Help to Align Activities and Assessments. *HAPS Educator*, *24*(1), 592–599. https://doi.org/10.21692/haps.2020.006

Dahlstrom-Hakki, I. H., & Alstad, Z. G. (2019). Challenges Assessing the Conceptual Understanding of Students With Disabilities in Statistics. *Learning Disability Quarterly*, *42*(3), 175–185. https://doi.org/10.1177/0731948718817222

DeMara, R. F., Tian, T., & Howard, W. (2019). Engineering assessment strata: A layered approach to evaluation spanning Bloom's taxonomy of learning. *Education and Information Technologies*, *24*(2), 1147–1171. https://doi.org/10.1007/s10639-018-9812-5

Karim, M. A. (2021). Hybrid and Online Synchronous Delivery of Environmental Engineering During COVID-19 Pandemic: A Comparative Study on Perception, Attitude, and Assessment. *European Journal of STEM Education*, *6*(1). https://doi.org/10.20897/ejsteme/9688

Lenchuk, I., & Ahmed, A. (2021). Tapping into Bloom Taxonomy's Higher-Order Cognitive Processes: The Case for Multiple Choice Questions as a Valid Assessment Tool in the ESP Classroom. *Arab World English Journal*, *1*, 160–171. https://doi.org/10.24093/awej/covid.12

Nelson, R., Marone, V., Garcia, S. A., Yuen, T. T., Bonner, E. P., & Browning, J. A. (2021). Transformative Practices in Engineering Education: The Embedded Expert Model. *IEEE Transactions on Education*, *64*(2), 187–194. https://doi.org/10.1109/TE.2020.3026906

Smolinsky, L., Marx, B. D., Olafsson, G., & Ma, Y. A. (2020). Computer-based and paper-and-pencil tests: A study in calculus for STEM majors. *Journal of Educational Computing Research, 58*(7), 1256-1278. https://doi.org/10.1177/0735633120930235.

References – Assignments/Projects

Bopegedera, A. M. R. P. (2020). Using familiar and new assessment tools in physical chemistry courses during covid-19. *Journal of Chemical Education*, *97*(9), 3260–3264. https://doi.org/10.1021/acs.jchemed.0c00789

Bush, E. C., Adolph, S. C., Donaldson-Matasci, M. C., Hur, J., & Schulz, D. (2021). Incorporating Programming, Modeling, and Data Analysis Into a Biology Course. *Journal of College Science Teaching, 50*(3).

Clark, R. M., & Mahboobin, A. (2018). Scaffolding to Support Problem-Solving Performance in a Bioengineering Lab - A Case Study. *IEEE Transactions on Education*, *61*(2), 109–118. https://doi.org/10.1109/TE.2017.2755601

Gil, P. (2017). Short Project-Based Learning with MATLAB Applications to Support the Learning of Video-Image Processing. *Journal of Science Education and Technology*, *26*(5), 508–518. https://doi.org/10.1007/s10956-017-9695-z

Kalajdzievska, D. (2014). Taking Math Students From "Blah" to "Aha": What can we do? *PRIMUS*, *24*(5), 375–391. https://doi.org/10.1080/10511970.2014.893937

Lewis, M., & Powell, J. A. (2016). Modeling Zombie Outbreaks: A Problem-Based Approach to Improving Mathematics One Brain at a Time. *PRIMUS, 26*(7). https://doi.org/10.1080/10511970.2016.1162236.

Yao, G., Black, K., Ramsdell, M., & Skufca, J. (2020). CoOrdinated Math-Physics Assessment as an Alternative Pathway in Early STEM. *PRIMUS*, *30*(1), 97–122. https://doi.org/10.1080/10511970.2018.1506533

References – In-Class Assessments

Canfield, S., & Abdelrahman, M. (2012). Enhancing the Programming Experience for First-Year Engineering Students through Hands-On Integrated Computer Experiences. *Journal of STEM Education, 13.*

Connell, G. L., Donovan, D. A., & Chambers, T. G. (2016). Increasing the use of student-centered pedagogies from moderate to high improves student learning and attitudes about biology. *CBE Life Sciences Education*, *15*(1). https://doi.org/10.1187/cbe.15-03-0062

Dosa, K., & Russ, R. (2016). Beyond Correctness: Using Qualitative Methods to Uncover Nuances of Student Learning in Undergraduate STEM Education. *Journal of College Science Teaching, 46*(2).

Gómez-Espina, R., Rodriguez-Oroz, D., Chávez, M., Saavedra, C., & Bravo, M. J. (2019). Assessment of the socrative platform as an interactive and didactic tool in the performance improvement of STEM University students. *Higher Learning Research Communications*, *9*(2). https://doi.org/10.18870/hlrc.v9i2.438

Gray, K., Owens, K., Liang, X., & Steer, D. (2012). Assessing Multimedia Influences on Student Responses Using a Personal Response System. *Journal of Science Education and Technology*, *21*(3), 392–402. https://doi.org/10.1007/s10956-011-9332-1

Koenig, K., Wood, K. E., Bortner, L. J., & Bao, L. (2019). Modifying Traditional Labs to Target Scientific Reasoning. *Journal of College Science Teaching, 48*(5), 28-35.

Kruse, G., & Drews, D. (2013). Using Performance Tasks to Improve Quantitative Reasoning in an Introductory Mathematics Course. *International Journal for the Scholarship of Teaching and Learning*, *7*(2). https://doi.org/10.20429/ijsotl.2013.070219

Nielsen, L.P., Bean, W.N., & Larsen, A.A.R. (2018). The Impact of a Flipped Classroom Model of Learning on a Large Undergraduate Statistics Class 7. *Statistics Education Research Journal 7*(1), 121-140. http://www.stat.auckland.ac.nz/serj

Rosenblatt, R., Heckler, A. F., & Flores, K. (2013). A Tutorial Design Process Applied to an Introductory Materials Engineering Course. *Advances in Engineering Education, 3*(3).

Scalise, K., Douskey, M., & Stacy, A. (2018). Measuring learning gains and examining implications for student success in STEM. *Higher Education Pedagogies*, *3*(1), 183–195. https://doi.org/10.1080/23752696.2018.1425096

Zhao, D., Muntean, C. H., Chis, A. E., & Muntean, G. M. (2021). Learner Attitude, Educational Background, and Gender Influence on Knowledge Gain in a Serious Games-Enhanced Programming Course. *IEEE Transactions on Education*, *64*(3). https://doi.org/10.1109/TE.2020.3044174

References – Self-Learning/Mastery Grading

Beumann, S., & Wegner, S. A. (2018). An outlook on self-assessment of homework assignments in higher mathematics education. *International Journal of STEM Education*, *5*(1). https://doi.org/10.1186/s40594-018-0146-z

Gozzard, D. R., & Zadnik, M. G. (2021). Contribution of self-directed, naked-eye observations to students' conceptual understanding and attitudes towards astronomy. *Physical Review Physics Education Research*, *17*(1). https://doi.org/10.1103/PhysRevPhysEducRes.17.010134

Harsy, A. (2020). Variations in Mastery-Based Testing. *PRIMUS*, *30*(8–10), 849–868. https://doi.org/10.1080/10511970.2019.1709588

Harsy, A., & Hoofnagle, A. (2020). Comparing Mastery-based Testing with Traditional Testing in Calculus II. *International Journal for the Scholarship of Teaching and Learning*, *14*(2). https://doi.org/10.20429/ijsotl.2020.140210

Howard, E., Meehan, M., & Parnell, A. (2019). Quantifying participation in, and the effectiveness of, remediating assessment in a university mathematics module. *Assessment and Evaluation in Higher Education*, *44*(1), 97–110. https://doi.org/10.1080/02602938.2018.1476670

Karaali, G. (2015). Metacognition in the Classroom: Motivation and Self-Awareness of Mathematics Learners. *PRIMUS*, *25*(5), 439–452. https://doi.org/10.1080/10511970.2015.1027837

Koskinen, P., Lämsä, J., Maunuksela, J., Hämäläinen, R., & Viiri, J. (2018). Primetime learning: collaborative and technology-enhanced studying with genuine teacher presence. *International Journal of STEM Education*, *5*(1). https://doi.org/10.1186/s40594-018-0113-8

Mingus, T. T. Y., & Koelling, M. (2021). A Collaborative Approach to Coordinating Calculus 1 to Improve Student Outcomes. *PRIMUS*, *31*(3–5), 393–412. https://doi.org/10.1080/10511970.2020.1772919

Posner, M. (2011). The impact of a proficiency-based assessment and reassessment of learning outcomes system on student achievement and attitudes. *Statistics Education Research Journal, 10*(1).

Velegol, S. B. (2015, June 14-17). *Quiz re-takes: Which students take advantage and how does it affect their performance?* [Paper presentation]. 122nd American Society for Engineering Education Annual Conference and Exposition, Seattle, WA, United States.

Walck-Shannon, E. M., Cahill, M. J., McDaniel, M. A., & Frey, R. F. (2019). Participation in voluntary re-quizzing is predictive of increased performance on cumulative assessments in introductory biology. *CBE Life Sciences Education*, *18*(2). https://doi.org/10.1187/cbe.18-08-0163

Weir, R. J. (2020). Rethinking Precalculus and Calculus: A Learner-Centered Approach. *PRIMUS*, *30*(8–10), 995–1016. https://doi.org/10.1080/10511970.2019.1686669

References – Communication/Other

Boyle, B., Mitchell, R., McDonnell, A., Sharma, N., Biswas, K., & Nicholas, S. (2020). Overcoming the challenge of "fuzzy" assessment and feedback. *Education and Training*, *62*(5), 505–519. https://doi.org/10.1108/ET-08-2019-0183

Chen, B., Bastedo, K., & Howard, W. (2018). Exploring design elements for online STEM courses: Active learning, engagement & assessment design. *Online Learning Journal*, *22*(2), 59–76. https://doi.org/10.24059/olj.v22i2.1369

Goodman, A. L. (2020). Can group oral exams and team assignments help create a supportive student community in a biochemistry course for nonmajors? *Journal of Chemical Education*, *97*(9), 3441–3445. https://doi.org/10.1021/acs.jchemed.0c00815

Kogl Camfield, E., & Land, K. M. (2017). The Evolution of Student Engagement: Writing Improves Teaching in Introductory Biology Courses*, Bioscene, 43*(1).

Reyna, J., & Meier, P. (2020). Co-creation of knowledge using mobile technologies and digital media as pedagogical devices in undergraduate STEM education. *Research in Learning Technology*, *28*. https://doi.org/10.25304/rlt.v28.2356

Sato, B. K., Hill, C. F. C., & Lo, S. M. (2019). Testing the test: Are exams measuring understanding? *Biochemistry and Molecular Biology Education*, *47*(3), 296–302. https://doi.org/10.1002/bmb.21231