Tracking Your STA496 Searches

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Search Terms	Where I searched	Date of Search	Limits I used	# of results
"life science statistics education"	Google Scholar	May 24, 2026	Since 2022	158,000

Relevance of Results

(*Are results relevant to your topic? If so, how? If not, how can you modify your search to find better results?)*

The results yielded from the search term "life science statistics education" on Google Scholar, limiting papers to since 2022, were generally relevant. However, for the purposes of this study it may be useful to refine future searches to studies which specifically focus on restructuring existing undergraduate level life science courses to improve research output and/or learning outcomes. By comparison, the search term "life science statistics education" appeared to yield a broader range of papers (ex: integrating humanities into data science education, statistics for aware citizenship), not necessarily pertaining to the aforementioned topic. One way to modify future searches to find better results would be to try search terms such as "life science statistics education x", where x is a word which could take on restructuring, improvement, undergraduate, research as potential terms.

Citations for further Reading

Furrer, E., Cincera, A., & Furrer, R. (2024). More than Formulas--Integrity, Communication, Computing and Reproducibility in Statistics Education. *arXiv preprint arXiv:2407.08835*.

Kulacki, A. R., & Aikens, M. L. (2026). Examining Motivational Attitudes Toward Statistics and Their Relationship to Performance in Life Science Students. Journal of Statistics and Data Science Education, 34(1), 36–47. https://doi.org/10.1080/26939169.2024.2365892

Lee, K. H., Ko, E. S., & Tak, B. (2023). A review of statistics education reform efforts in Korea. *Journal of Educational Research in Mathematics*, *33*(3), 479-505.

White, B., & Singh, J. (2024, March). Preparing future life science researchers to engage with statistics in research. In *IASE Conference Proceedings Series*.

Yenilmez, İ. (2026). eduMathStatAI: Enhancing Mathematics and Statistics Education Through Coding and Digital Tools. In *Effective Coding Skill Development in Education* (pp. 181-212). IGI Global Scientific Publishing.

Search Terms	Where I searched	Date of Search	Limits I used	# of results
"undergraduate statistics education restructure"	Google Scholar	May 24, 2026	Since 2022	17,200

Relevance of Results

(*Are results relevant to your topic? If so, how? If not, how can you modify your search to find better results?)*

The search term "undergraduate statistics education restructure" on Google Scholar, limiting papers to since 2022 yielded 17,200 results, some of which were interesting and appeared relevant to the topic of our study, "*Perspectives on Statistics Education in the Life Sciences".* Two results that appeared particularly relevant were ere the study by Mária Benková and colleagues (2022) and the more recent work by Dina Mizza and colleagues (2025), both of which focused on redesigning statistics instruction to improve student engagement and competency in quantitative disciplines. This could be relevant information to use when considering redesigning statistics undergraduate courses at UofT. Mizza's flipped classroom approach I found particularly interesting, as this is an approach which is implemented already in certain UofT couses including ECO101 , ECO206, both of which are quantitative economics courses. As such, this could be a promising approach which merits further investigation for UofT Statistics life science courses.

Citations for further Reading

Benková, M., Bednárová, D., Bogdanovská, G., & Pavlíčková, M. (2022). Redesign of the statistics course to improve graduates' skills. *Mathematics*, *10*(15), 2569.

Mizza, D., Reese, M., & Malouche, D. (2025). Flipped classroom evaluation and blended learning potential: a case study of engagement and inclusion in quantitative education. *Smart Learning Environments*, *12*(1), 56.

Search Terms	Where I searched	Date of Search	Limits I used	# of results
"bioinformatics" AND "education" AND "undergraduate"	Google Scholar	June 1, 2026	None	43,700

Relevance of Results

(*Are results relevant to your topic? If so, how? If not, how can you modify your search to find better results?)*

The search results yielded by the Google Scholar prompt *"bioinformatics" AND "education" AND "undergraduate"* yielded very relevant results: I was very pleased that the combination of search terms *bioinformatics, education,* and *undergraduate* outputted many peer-reviewed papers related to the integration of bioinformatics (a subfield of Statistics) at the undergraduate course level and current challenges with integration. In the *"Citations for further Reading" section*, I decided to select three articles from the outputted results, each delving into the challenges related to incorporating bioinformatics into undergraduate instruction. Better understanding the challenges discussed in the papers may assist in identifying current challenges related to bioinformatics undergraduate course integration here at the University of Toronto, as well as potential solutions.

Citations for further Reading

Cummings, M. P., & Temple, G. G. (2010). Broader incorporation of bioinformatics in education: opportunities and challenges. Briefings in bioinformatics, 11(6), 537-543.

Hack, C., & Kendall, G. (2005). Bioinformatics: Current practice and future challenges for life science education. Biochemistry and Molecular Biology Education, 33(2), 82-85.

Williams, J. J., Drew, J. C., Galindo-Gonzalez, S., Robic, S., Dinsdale, E., Morgan, W. R., ... & Pauley, M. A. (2019). Barriers to integration of bioinformatics into undergraduate life sciences education: A national study of US life sciences faculty uncover significant barriers to integrating bioinformatics into undergraduate instruction. PLoS One, 14(11), e0224288.

Search Terms	Where I searched	Date of Search	Limits I used	# of results
"quantitative" AND "education" AND "undergraduate"	Google Scholar	June 1, 2026	Since 2022	254,000

Relevance of Results

(*Are results relevant to your topic? If so, how? If not, how can you modify your search to find better results?)*

Not great, too broad

Citations for further Reading

Tan, K. S., Elkin, E. B., & Satagopan, J. M. (2022). A model for an undergraduate research experience program in quantitative sciences. *Journal of statistics and data science education*, *30*(1), 65-74.

Search Terms	Where I searched	Date of Search	Limits I used	# of results
"undergraduate" AND “statistics education” AND “improvement”	Google Scholar	June 1, 2026	Since 2022	2,310

Relevance of Results

(*Are results relevant to your topic? If so, how? If not, how can you modify your search to find better results?)*

Better, tried to improve search term above to target statistics. Reason for leaving “life science” term out: wanted to see papers which may have improved curriculum design for non-life science students – perhaps there are transferable strategies there? Found one innovating for a first-year undergraduate Business Analytics course. Many of the collected citations below are related to how specifically first-year learning can be improved for statistics education. First-year is a critical period for learning statistics – interested in how we can improve statistics education for future researchers by laying good foundations in first year, and the citations collected below are intended to reflect that scope.

Citations for further Reading

Conlon, B., & Wilson, S. (2025). Enhancing statistics education through student-generated data and authentic assessment. Assessment & Evaluation in Higher Education, 1-20.

Da Silva, L. (2023). Flipping the classroom to enhance student engagement in first-year statistics education (Doctoral dissertation, University of the Free State).

Tan, A. J., Davies, J. L., Nicolson, R. I., & Karaminis, T. (2023). A technology-enhanced learning intervention for statistics in higher education using bite-sized video-based learning and precision teaching. Research and Practice in Technology Enhanced Learning.

Search Terms	Where I searched	Date of Search	Limits I used	# of results

"undergraduate" AND “statistics education” AND “improvement” AND “first year”	Google Scholar	June 3, 2026	None	708

Relevance of Results

(*Are results relevant to your topic? If so, how? If not, how can you modify your search to find better results?)*

Following the first-year focus from the set of collected citations above with search term “"undergraduate" AND “statistics education” AND “improvement””, I explicitly modified the Google Scholar search term by including “first year”, keeping all other key words from the last search term present. This yielded the smallest number of results yet, at only 708 results. I collected citations which had to do with improving statistical education at the undergraduate level for first years specifically. While I did not include any life-science specific terms here, I hope to bridge findings from citations generated from earlier life-science specific search terms and findings here, to understand strategies to improve first-year statistical education for life science students at the undergraduate level. While this may appear very narrow, my hope is that the focus on effective learning first-years – who are often being exposed to a topic for the first time, unfamiliar, may have inaccurate perceptions regarding statistics – can expose transferable learning outcomes for any “inexperienced” learner, which is the case for many life science students at any level of undergrad, given statistics is outside their domain of mastered learning.

Citations for further Reading

Axelsen, T., King, R., & Curtis, E. (2025). Visualising and evaluating learning/achievement consistency in introductory statistics. *Cogent Education*, *12*(1), 2492727.

Boitshwarelo, B., & Jayasinghe, M. (2024). Enhancing Online Teaching of Business Statistics: A Pedagogy Before Technology Approach. *International Review of Research in Open and Distributed Learning*, *25*(1), 240-254.

Harris, J. (2023). Statistical Success: Three-Year Analysis of Student Performance and Student Insights from a First-Year College Statistics Course. *Advances in Social Sciences Research Journal*, *10*(5), 103.

Search Terms	Where I searched	Date of Search	Limits I used	# of results
"undergraduate" AND “statistics education” AND “CHATGPT”	Google Scholar	June 3, 2026	None	364

Relevance of Results

(*Are results relevant to your topic? If so, how? If not, how can you modify your search to find better results?)*

The results were relevant to the topic, yielding several studies directly examining the impact of ChatGPT and generative AI on undergraduate statistics education. The citations identified (Ahmed, Zaid, and Abdullah (2025), Dunn (2025), and Wahba, Ajlouni, and Abumosa (2024)) address student motivation, engagement, statistical reasoning, attitudes, and academic performance in relation to AI-assisted learning, all of which align closely with the intended focus of this study.

However, while the results were relevant, they were relatively few in number and highly specific, suggesting the search terms may be too narrow. To broaden and strengthen the results for this study, the search could be modified to focus more directly on how ChatGPT can be integrated into statistics education, rather than only its general impact. Adjusting the search terms to something like "ChatGPT" AND "statistics education" AND "integration" (or "pedagogy"/"instructional design") may surface more studies focused on implementation strategies, which would be more applicable to informing curriculum design recommendations.

Citations for further Reading

Ahmed, M., Zaid, N. M., & Abdullah, A. H. B. (2025). The impact of integration of AI in statistics learning on student motivation and learning engagement in higher education sector. *International Journal of Academic Research in Progressive Education and Development*, *14*(1), 426-436.

Dunn, P. K. (2025). Generative AI may impact students' marks: a case study from a large first-year statistics course. International Journal of Mathematical Education in Science and Technology, 1-14.

Wahba, F., Ajlouni, A. O., & Abumosa, M. A. (2024). The impact of ChatGPT-based learning statistics on undergraduates' statistical reasoning and attitudes toward statistics. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(7), em2468.

Search Terms	Where I searched	Date of Search	Limits I used	# of results
"undergraduate" AND "statistics education" AND "CHATGPT" AND "using"	Google Scholar	June 8, 2026	None	356

Relevance of Results

(*Are results relevant to your topic? If so, how? If not, how can you modify your search to find better results?)*

As mentioned above, the search was modified to be more applicable to this study by focusing on how ChatGPT can be integrated into statistics education, rather than its impact in general. The results were relevant, as the citations collected allow for an assessment of whether integrating ChatGPT into statistics instruction is overall beneficial or detrimental, based on findings related to student engagement, reasoning, and performance. To further improve relevance, the next search will incorporate a life-science-specific term, narrowing the focus to statistics education within that disciplinary context. The tradeoff is that this added specificity may significantly reduce the number of results.

Citations for further Reading

Al-Labadi, L., Jazi, O. A., Ataei, M., Bao, K., & Yu, R. (2025). AI Meets Academia: Enhancing Statistics Education with ChatGPT in Undergraduate Courses. *TechTrends*, 1-9.

Al Labadi, L., & Ly, A. (2025). Enhancing statistics education through Project-Based Learning (PBL) and the emergence of ChatGPT. *Teaching Statistics*, *47*(3), 200-218.

Wahba, F., Ajlouni, A. O., & Abumosa, M. A. (2024). The impact of ChatGPT-based learning statistics on undergraduates' statistical reasoning and attitudes toward statistics. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(7), em2468.

Xing, Y. (2024). Exploring the use of ChatGPT in learning and instructing statistics and data analytics. *Teaching Statistics*, *46*(2), 95-104.

Search Terms	Where I searched	Date of Search	Limits I used	# of results
"undergraduate" AND "statistics education" AND "CHATGPT" AND "using" AND "life science"	Google Scholar	June 8, 2026	None	9

Relevance of Results

(*Are results relevant to your topic? If so, how? If not, how can you modify your search to find better results?)*

As noted in the search term log above, "life science" was added to the previous search term to narrow the focus further. This yielded only 9 results, but they were extremely relevant to this narrow scope. These results are expected to improve understanding of how curricula can bridge the gap between students' increasing (and sometimes unauthorized) use of AI tools and the need for stronger statistics learning outcomes at the undergraduate life science level. Given the high relevance despite the small number of results, no further modification appears necessary at this stage, though future searches could explore related terms (e.g., "biology" or "life sciences curriculum") to capture additional relevant studies if needed.

Citations for further Reading

Ghaleb, M. M. S., & Otamurodov, S. (2026). Leveraging Authentic Learning and Open Data to Foster Epistemic Curiosity and Statistical Reasoning in Biostatistics Education. *Letters in Biomathematics*, *13*(1), 27-41.

Zhuang, M., Kirby, C., Stoltzfus, J. R., Krueger, K., Liu, J., Mias, G., & Parkin, K. (2025). Comparing Online and In-Person Learning Outcomes with Synchronous Hybrid Instruction: A Natural Experiment During COVID-19. *Journal of Science Education and Technology*, 1-15.

Search Terms	Where I searched	Date of Search	Limits I used	# of results
"what topics are needed in undergraduate life science statistics education"	Google Scholar	June 10, 2026	None	931,000

Relevance of Results

(*Are results relevant to your topic? If so, how? If not, how can you modify your search to find better results?)*

This search aimed to identify what undergraduate life science students should be learning regarding statistics, as opposed to how that content should be taught. The results were relevant in that they shifted the focus toward curriculum content rather than instructional methods, providing

insight into the foundational statistical concepts and skills considered essential for this student population. If results are limited or too broad, the search could be refined by adding terms such as "curriculum" or "learning outcomes" to more precisely target sources discussing required statistical competencies for life science undergraduates.

For my most recent search, I used Google Scholar as the search engine, with the search phrase "what topics are needed in undergraduate life science statistics education." This search returned an extremely large number of results (approximately 931,000) likely because the query was phrased as a natural-language question rather than using more targeted keyword combinations or quotation marks around specific terms. While the breadth of results suggests low specificity, the top results that appeared were still highly relevant to the focus of this study, surfacing key sources discussing core statistical competencies and curriculum content for undergraduate life science students.

The citation of an "ideal" result from my last search is "Baldi, B., & Utts, J. (2015). What your future doctor should know about statistics: must-include topics for introductory undergraduate biostatistics. *The American Statistician*, *69*(3), 231-240.", including keywords "statistics", "introductory", "undergraduate" and "biostatistics". In the future, I could adjust my keywords to include more "biostatistics" specific terms, since biostatistics is a common bridge field between statistics and life science, in addition to continuing to use key words such as "undergraduate". "Introductory" is another key word I had not previously considered integrating into my searches which may be relevant for finding information regarding statistics education for those not in quantitative disciplines such as mathematics, computer science or statistics.

Citations for further Reading

Baldi, B., & Utts, J. (2015). What your future doctor should know about statistics: must-include topics for introductory undergraduate biostatistics. *The Americanl Statistician*, *69*(3), 231-240.

Schwab-McCoy, A. (2019). The state of statistics education research in client disciplines: Themes and trends across the university. *Journal of Statistics Education*, *27*(3), 253-264.

Wilson Sayres, M. A., Hauser, C., Sierk, M., Robic, S., Rosenwald, A. G., Smith, T. M., ... & Pauley, M. A. (2018). Bioinformatics core competencies for undergraduate life sciences education. *PloS one*, *13*(6), e0196878.

Search Terms	Where I searched	Date of Search	Limits I used	# of results
"enhance" "statistics education"	Google Scholar	June 28, 2026	None	15,800

Relevance of Results

(*Are results relevant to your topic? If so, how? If not, how can you modify your search to find better results?)*

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Citations for further Reading

Awunkori, E., & Matta, V. (2026). Statistics education rebooted in the age of artificial intelligence. Journal of Decision Systems, 35(1), 2657509.

Hasim, S., Rosli, R., & Halim, L. (2024). A systematic review on teaching strategies for fostering students' statistical thinking. International Journal of Learning, Teaching and Educational Research, 23(1), 136-158.

Tishkovskaya, S., & Lancaster, G. A. (2012). Statistical Education in the 21st Century: A Review of Challenges, Teaching Innovations and Strategies for Reform. Journal of Statistics Education, 20(2). https://doi.org/10.1080/10691898.2012.11889641.