Background information and annotated references

UDL provides evidence-based solutions that address barriers to student success ranging from physical accessibility of the classroom to cognitive access to cultivation of learner self-efficacy (Meyer et al., 2014). Removing these barriers can create more inclusive STEM classrooms which can increase motivation and improve learner outcomes (Dewsbury & Brame 2019; Rao et al., 2014; Schreffler et al., 2019; Yeager et al., 2019). UDL can address the likely future need of more flexible and adaptable learning experiences (Meyer et al., 2014; Wong, 2020). UDL principles also help students develop critical thinking skills, problem solving skills and metacognition (Orndorf et al 2022)).

The UDL framework presents its guidelines through a goal-focused approach that allows faculty to identify where they have already implemented UDL and identify future applications that will be most impactful to their learners (Tobin & Behling, 2018). This approach leads to better outcomes for learners and reduced frustration for instructors (Kumar & Wideman, 2014; Rao et al., 2014).

UDL specifically addresses **access** to ensure learners can physically engage with materials, and where “accessibility” issues are addressed. Access also includes ensuring the learning environment provides relevance and authenticity for students, offers multiple formats for interacting with material (e.g. text and audio), and uses technology that is designed for a broad range of users (e.g. options for using mouse commands and keyboard shortcuts). UDL advocates that faculty provide learning environments that support student persistence, provide disciplinary expertise by clarifying and “decoding” disciplinary information, and scaffold students’ ability to demonstrate mastery of disciplinary practices. It focuses on the development of higher order learning and metacognitive skills that support students in becoming experts in how they learn. Skills include self-regulation, developing coping skills and strategies, ability to transfer knowledge across domains, engagement in disciplinary core concepts, and the application of appropriate metacognitive practices to enhance learning. The UDL Framework is available on the CAST website, and a rubric exploring each aspect deeply is available (Novak and Rodriguez, 2018).

CAST. (2018). **Universal Design for Learning guidelines, version 2.2**. Retrieved June 3, 2021, from <http://udlguidelines.cast.org> [Google Scholar](https://scholar.google.com/scholar_lookup?hl=en&publication_year=2018&author=CAST&title=Universal+Design+for+Learning+guidelines%2C+version+2.2)

CAST. (2011). *Universal Design for Learning Guidelines version 2.0.* Wakefield, MA.

Chardin, M., & Novak, K. (2021). *Equity by design Delivering on the power and promise of UDL*. Corwin A Sage Company.

This book is a guide for designing and implementing culturally responsive and equitable learning experiences. It has explicit strategies and examples, uses research as well as the voices of educators/students practicing Universally Designed social justice. Although designed for K12 education, college instructors will find many good examples and thoughtful reflection exercises about teaching practices.

Dou, R. (2021). *Constructing STEM identity : An expanded structural model for STEM identity research*. *May 2020*. <https://doi.org/10.1002/tea.21734>

Dewsbury, B., & Brame, C. J. (2019). *Inclusive teaching.* CBE—Life Sciences Education, 18(2), <https://doi.org/10.1187/cbe.19-01-0021>

This paper describes the online, evidence-based teaching guide (<https://lse.ascb.org/evidence-based-teaching-guides/inclusive-teaching>) . It features suggestions on reflection on practice and developing awareness and empathy. It also includes a tool for evaluating and thinking about these concepts. The tool is available as a pdf.

Fritzgerald, A. (2020). *Anti-racism and universal design for learning: Building expressways to success*. CAST, Inc.

Another book designed for K12 educators, but teaches many lessons that college faculty can benfit from.

Kumar, K. L., & Wideman, M. (2014). *Accessible by design: Applying UDL principles in a first year undergraduate course.* Canadian Journal of Higher Education, 44(1), 125-147. <https://doi.org/10.47678/cjhe.v44i1.183704>

McKeown, C., & McKeown, J. (2019). *Accessibility in online courses: understanding the deaf learner.* TechTrends, 63(5), 506-513. <https://doi.org/10.1007/s11528-019-00385-3>

Meyer, A., Rose, D.H., & Gordon, D. (2014). *Universal design for learning: Theory and Practice.* Wakefield, MA: CAST Professional Publishing.

National Center for Science and Engineering Statistics (NCSES). (2019). *Women, Minorities, and Persons with Disabilities in Science and Engineering.*<https://ncses.nsf.gov/pubs/nsf19304>

National Research Council. (2015). *Reaching Students: What Research Says About Effective Instruction in Undergraduate Science and Engineering*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/18687>

Novak, K., & Rodriguez, K. (2018). *UDL progression rubric.*

Orndorf, H. C., Waterman, M., Lange, D., Kavin, D., Johnston, S. C., & Jenkins, K. P. (2022). *Opening the Pathway: An Example of Universal Design for Learning as a Guide to Inclusive Teaching Practices.* CBE-Life Science Education Vol 21, No 2<https://doi.org/10.1187/cbe.21-09-0239>

Orndorf, H. (2022). [*Beyond Average: Designing for Variability with Universal Design for Learning*](http://dx.doi.org/10.25334/QRRW-N659)*.* [*Universal Design for Learning*](https://qubeshub.org/groups/udl)*,* QUBES Educational Resources. [doi:10.25334/QRRW-N659](http://dx.doi.org/10.25334/QRRW-N659)

Rao, K., Ok, M. W., & Bryant, B. R. (2014). A review of research on universal design educational models. *Remedial and special education*, *35*(3), 153-166. <https://doi.org/10.1177%2F0741932513518980>

Reinholz, D. L., & Ridgway, S. W. (2021). Access needs: Centering students and disrupting ableist norms in STEM. CBE Life Sciences Education, 20(3), es8-es8. https://doi.org/10.1187/cbe.21-01-0017

Rose, D.H. & Gravel, J.W. (2010). *Universal design for learning.* In E. Baker, P. Peterson, & B. McGaw (Eds.). International Encyclopedia of Education, 3rd Ed. Oxford: Elsevier.

Rose, D. H., Harbour, W. S., Johnston, C. S., Daley, S. G., & Abarbanell, L. (2006). *Universal design for learning in postsecondary education: Reflections on principles and their application.* Journal of postsecondary education and disability, 19(2), 135-151.

Schreffler, J., Vasquez III, E., Chini, J., & James, W. (2019). *Universal design for learning in postsecondary STEM education for students with disabilities: A systematic literature review.* International Journal of STEM Education, 6(1), 1-10. <https://doi.org/10.1186/s40594-019-0161-8>

Tobin, T. J., & Behling, K. T. (2018). *Reach everyone, teach everyone: Universal design for learning in higher education.* West Virginia University Press.

University of Michigan Center for Research on Learning & Teaching. (2021).[*Reflecting on Your Practice: Applying Equity-Focused Teaching Principles*](https://docs.google.com/document/d/1wsoF0NgRbj1IZFM8H7FXydbBgxUlKfQchwHLrjMQu8E/edit#heading=h.rgsvonbh9hpa)*.*

van Rooij, S. W., & Zirkle, K. (2016). *Balancing pedagogy, student readiness and accessibility: A case study in collaborative online course development. The Internet and Higher Education,* 28, 1-7. <https://doi.org/10.1016/j.iheduc.2015.08.001>

Novak, K., & Rodriguez, K. (2018). **UDL progression rubric**. Retrieved June 2, 2021, from [http://castpublishing.org/wp-content/uploads/2018/02/UDL \_Progression\_Rubric\_FINAL\_Web\_REV1.pdf](http://castpublishing.org/wp-content/uploads/2018/02/UDL_Progression_Rubric_FINAL_Web_REV1.pdf) [Google Scholar](https://scholar.google.com/scholar_lookup?hl=en&publication_year=2018&author=K.+Novak&author=K.+Rodriguez&title=UDL+progression+rubric)

Tobin, T. J., & Behling, K. T. (2018). **Reach everyone, teach everyone: Universal Design for Learning in higher education**. Morgantown, WV: West Virginia University Press. [Google Scholar](https://scholar.google.com/scholar_lookup?hl=en&publication_year=2018&author=T.+J.+Tobin&author=K.+T.+Behling&title=Reach+everyone%2C+teach+everyone%3A+Universal+Design+for+Learning+in+higher+education)

U.S. Bureau of Labor Statistics. (2021, September 8). **Occupational outlook handbook***.* Retrieved November 10, 2021, from [www.bls.gov/ooh/life -physical-and-social-science/home.htm](http://www.bls.gov/ooh/life-physical-and-social-science/home.htm) [Google Scholar](https://scholar.google.com/scholar_lookup?hl=en&publication_year=2021&author=U.S.+Bureau+of+Labor+Statistics&title=Occupational+outlook+handbook)

Orndorf, H. C., Waterman, M., Lange, D., Kavin, D., Johnston, S. C., & Jenkins, K. P. (2022). Opening the Pathway: An Example of Universal Design for Learning as a Guide to Inclusive Teaching Practices. *CBE—Life Sciences Education*, *21*(2), ar28. <https://doi.org/10.1187/cbe.21-09-0239>

.

Parker, H. B. (2012). Learning starts with design: Using universal design for learning (UDL) in higher education course redesign. *Transforming learning environments: Strategies to shape the next generation*.

Rushworth, J., Graham Lawson, U. J., Desai, N. J., & Moriarty, A. 5 A novel bioscience ‘capstudy’assessment based on Universal Design for Learning (UDL). *Notes on contributors*, 69.

Chardin, M., & Novak, K. (2021). *Equity by design Delivering on the power and promise of UDL*. Corwin A Sage Company.

Braun, D. C., Clark, M. D., Marchut, A. E., Solomon, C. M., Majocha, M., Davenport, Z., ... & Gormally, C. (2018). Welcoming deaf students into STEM: Recommendations for university science education. **CBE—Life Sciences Education**, *17*(3), es10. [Link](https://www.lifescied.org/doi/10.1187/cbe.17-05-0081), [Google Scholar](https://scholar.google.com/scholar_lookup?hl=en&volume=17&publication_year=2018&pages=es10&journal=CBE%E2%80%94Life+Sciences+Education&issue=3&author=D.+C.+Braun&author=M.+D.+Clark&author=A.+E.+Marchut&author=C.+M.+Solomon&author=M.+Majocha&author=Z.+Davenportauthor=C.+Gormally&title=Welcoming+deaf+students+into+STEM%3A+Recommendations+for+university+science+education)

Braun, D. C., Gormally, C., & Clark, M. D. (2017). The Deaf Mentoring Survey: A community cultural wealth framework for measuring mentoring effectiveness with underrepresented students. **CBE—Life Sciences Education**, *16*(1), ar10. [Link](https://www.lifescied.org/doi/10.1187/cbe.15-07-0155), [Google Scholar](https://scholar.google.com/scholar_lookup?hl=en&volume=16&publication_year=2017&pages=ar10&journal=CBE%E2%80%94Life+Sciences+Education&issue=1&author=D.+C.+Braun&author=C.+Gormally&author=M.+D.+Clark&title=The+Deaf+Mentoring+Survey%3A+A+community+cultural+wealth+framework+for+measuring+mentoring+effectiveness+with+underrepresented+students)

### [Opening the Pathway: An Example of Universal Design for Learning as a Guide to Inclusive Teaching Practices](https://www.lifescied.org/doi/abs/10.1187/cbe.21-09-0239)

HC Orndorf, M Waterman, D Lange… - CBE—Life Sciences …, 2022 - Am Soc Cell Biol

… pedagogical practices, specifically **case**-**based** **learning**, inclusive and **UDL**-aligned in an …   
of applying **UDL** to introductory biology at the high school and **community** **college** levels to …

### [Learning starts with design: Using universal design for learning (UDL) in higher education course redesign](https://www.emerald.com/insight/content/doi/10.1108/S1479-3660(2012)0000016009/full/html?utm_source=TrendMD&utm_medium=cpc&utm_campaign=Advances_in_Educational_Administration_TrendMD_1)

[HB Parker](https://scholar.google.com/citations?user=c8VO-l8AAAAJ&hl=en&oi=sra) - Transforming **learning** environments: Strategies to …, 2012 - emerald.com

… A **case**-**based** approach to professional development can provide time to see how faculty in   
… , With a Special Analysis of **Community** **College** Students:Eleven percent of undergraduates

Orndorf, H. (2022). [Beyond Average: Designing for Variability with Universal Design for Learning](http://dx.doi.org/10.25334/QRRW-N659). [Universal Design for Learning](https://qubeshub.org/groups/udl), QUBES Educational Resources. [doi:10.25334/QRRW-N659](http://dx.doi.org/10.25334/QRRW-N659)