

Promoting Equitable Access to Learning

Summary of the Literature

Promoting equitable access to learning means recognizing diversity in how students learn in the classroom and building course structures that support the learning of all students. It is critically important to address barriers to learning as a structural problem of the learning environment, not as a failing or limitation of the student. Additionally, promoting equitable access to learning does not mean compromising rigor in student achievement of the learning goals.

Structural barriers can arise in how students access and engage with course content and the learning environment, and in how they demonstrate their learning. Most barriers can be addressed by providing options, flexibility, and/or structure to the course. For example, providing course materials in different formats (e.g., text, audio, visual, and/or tactile) and utilizing technological tools with text-to-speech or language options can support a diversity of learners. Faculty can employ a mixture of techniques in the classroom such as active learning or collaborative/peer learning. Providing structure and explicit expectations to learning activities ensures all students are successful in participating. Finally, faculty can reduce barriers by engaging students' background experiences and preferences whether by providing students with choice in course materials or assessments or by incorporating diverse examples into course materials. These approaches empower students and enhance their motivation by making learning meaningful to them.

Successfully promoting equitable access to learning requires knowing one's students. Faculty can gain insight into their students by surveying students about their interests, preferences and needs, checking in with students about their social and emotional well-being, and asking students to self-assess and reflect on their learning process. Effective faculty regularly evaluate their teaching practices and make adjustments to support the learning of all students.

Annotated Bibliography

Empowering College Students: UDL, Culturally Responsive Pedagogy, and Mindset as an Instructional Approach

Gentile, Amber L., and Mary Budzilowicz. "Empowering college students: UDL, culturally responsive pedagogy, and mindset as an instructional approach." *New Directions for Teaching and Learning* 2022.172 (2022): 33-42.

Keywords

- Universal Design for Learning (UDL)
- Culturally Responsive Pedagogy (CRP)
- Growth Mindset
- Social Emotional Learning (SEL)
- Trauma Informed Practices (TIP)
- Inclusive Education

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Summary

The article explores the integration of Universal Design for Learning (UDL), Culturally Responsive Pedagogy (CRP), and Growth Mindset into a cohesive instructional approach aimed at addressing the diverse and holistic needs of college students. Emphasizing the importance of social-emotional learning (SEL) and trauma-informed practices (TIP), the authors present a model that supports student engagement, equity, and expert learning. This approach, grounded in research by Dweck, Hammond, and others, is designed to create an inclusive educational environment that values diversity and promotes student success through intentional and flexible instructional design. The authors provide practical strategies for implementing these principles within learning management systems to enhance student achievement.

Practical Actions Recommended

1. **Universal Design for Learning (UDL) Principles:**
 - Design curriculum that offers multiple means of engagement, representation, and expression to accommodate diverse learning needs.
 - Example: Use various formats for course materials (videos, podcasts, readings) and provide options for students to demonstrate their understanding (written assignments, presentations, creative projects).
2. **Culturally Responsive Pedagogy (CRP):**
 - Incorporate students' cultural backgrounds and experiences into the learning process to make it more relevant and engaging.
 - Example: Include diverse texts and perspectives in the curriculum and use culturally relevant teaching strategies such as storytelling and collaborative learning.
3. **Growth Mindset:**
 - Encourage a growth mindset by promoting the idea that abilities can be developed through effort and perseverance.
 - Example: Provide constructive feedback focused on students' efforts and strategies rather than their innate abilities, and create opportunities for students to reflect on their learning processes.
4. **Social Emotional Learning (SEL):**
 - Integrate SEL strategies to support students' emotional and social well-being, which are critical for effective learning.
 - Example: Start classes with check-ins to understand students' emotional states, use activities that build empathy and cooperation, and create a classroom environment that values each student's voice.
5. **Trauma Informed Practices (TIP):**
 - Implement TIP to create a safe and supportive learning environment for students who may have experienced trauma.
 - Example: Use a compassionate approach in interactions with students, provide clear and consistent expectations, and offer choices to empower students and reduce anxiety.
6. **Inclusive and Supportive Classroom Environment:**
 - Establish a classroom culture that fosters belonging and respects diversity.

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- Example: Greet students by name, use inclusive language, and create opportunities for all students to contribute and feel valued.
- 7. Flexible Course Design:**
- Design courses that are flexible and adaptable to meet the varying needs of students.
 - Example: Offer flexible deadlines and multiple ways for students to engage with the course content and demonstrate their learning.
- 8. Use of Learning Management Systems:**
- Leverage technology to support diverse learning needs and promote engagement.
 - Example: Use tools like discussion boards, interactive quizzes, and multimedia resources to create an interactive and accessible online learning environment.

Implementing Universal Design for Learning in the Higher Education Science Classroom

Kirsch, B. A., Bryan, T., & Hoferer, D. (2024). Implementing Universal Design for Learning in the Higher Education Science Classroom. *Journal of College Science Teaching*, 53(2), 135-139. doi:10.1080/0047231X.2024.2316939

Keywords

- Universal Design for Learning (UDL)
- inclusive pedagogy
- science teaching
- higher education
- faculty development
- student engagement

Summary

This article explores the application of Universal Design for Learning (UDL) in higher education science classrooms to create inclusive and accessible learning environments. The authors discuss a UDL Academy that introduced science faculty to the UDL framework, which led to its implementation in chemistry, physics, and environmental science courses. The framework, developed by CAST, is based on three principles: multiple means of engagement, representation, and action and expression. Faculty participants reported positive impacts on student engagement and learning outcomes. The article highlights the need for ongoing faculty training and the flexibility of UDL implementation, emphasizing the benefits of providing diverse learning materials and assessment options to accommodate all students.

Practical Actions Recommended

- 1. Provide Multiple Means of Engagement:**

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- **Captioning Presentations:** Use captions in presentations to assist students with different learning needs, including those who are hearing impaired or non-native English speakers.
 - Example: Incorporate automatic captions or transcripts for video lectures.
- 2. **Multiple Means of Representation:**
 - **Post Slides in Advance:** Allow students to print and review lecture slides before class to aid note-taking and comprehension.
 - Example: Upload slides to the course management system before each class session.
 - **Use E-books and Digital Resources:** Utilize e-books with text-to-speech options and embedded videos to cater to diverse learning preferences.
 - Example: Provide digital textbooks that offer various formats and languages.
- 3. **Multiple Means of Action and Expression:**
 - **Flexible Assessment Methods:** Offer multiple assessment types, such as traditional exams, online quizzes, and hands-on projects, to give students various ways to demonstrate their knowledge.
 - Example: Allow students to choose between writing a paper, creating a video presentation, or designing a website for their final project.
- 4. **Incremental Implementation:**
 - **Start Small:** Begin with simple UDL strategies and gradually expand to more comprehensive implementations.
 - Example: Introduce one or two UDL principles each semester to avoid overwhelming faculty and students.
- 5. **Student Choice and Autonomy:**
 - **Allow Choice in Assignments:** Let students select topics and formats for assignments to increase engagement and relevance to their interests and career goals.
 - Example: In a biology course, allow students to choose between creating a podcast, a children's book, or a traditional research paper for a project on vertebrate zoology.
- 6. **Mindful Memorization:**
 - **Balanced Approach to Memorization:** Encourage students to memorize key concepts while providing resources for other information.
 - Example: Allow formula sheets during exams to focus on application rather than rote memorization.
- 7. **Student-Selected Topics:**
 - **Incorporate Student Interests:** Allow students to propose and select topics for certain units to ensure the content is relevant and engaging.
 - Example: In an environmental science course, let students choose final exam topics based on their interests, such as marine conservation or emerging diseases.

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Access Needs: Centering Students and Disrupting Ableist Norms in STEM

Reinholz, D. L., & Ridgway, S. W. (2021). Access Needs: Centering Students and Disrupting Ableist Norms in STEM. *CBE—Life Sciences Education*, 20(es8), 1-8. doi:10.1187/cbe.21-01-0017

Keywords

- Access needs
- disability justice
- STEM education
- Accessibility
- Equity
- Universal Design for Learning (UDL)
- active learning
- inclusive teaching

Summary

This article explores the concept of access needs as a tool for improving accessibility in STEM education, from classrooms to research meetings and professional conferences. The authors argue that normalizing access talk—discussions about individual accessibility needs—can advance disability justice in STEM fields. The essay provides concrete strategies for normalizing access discussions, such as including access needs in introductions and conducting regular access check-ins. The authors emphasize that all individuals have access needs, regardless of disability status, and that addressing these needs is crucial for creating inclusive and equitable educational environments. The article highlights the importance of shifting from a deficit view of disability to one that recognizes and values the strengths and contributions of disabled individuals.

Practical Actions Recommended

1. **Normalize Access Needs in Introductions:**
 - **Access Check-Ins:** Incorporate access needs along with names and pronouns during introductions.
 - Example: “My name is Alex, my pronouns are they/them, and I need frequent breaks during long meetings.”
2. **Regular Access Needs Check-Ins:**
 - **Frequent Opportunities:** Regularly check in about access needs during classes, meetings, or collaborative tasks.
 - Example: Ask, “Are everyone’s access needs being met?” at the start and midway through class sessions.
3. **Provide Flexibility:**
 - **Adaptability:** Ensure that teaching methods and schedules allow for flexibility to accommodate varying access needs.
 - Example: Build in extra time in the schedule for unexpected adjustments based on students’ needs.
4. **Anonymous Feedback:**

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- **Private Channels:** Offer ways for students to anonymously communicate their access needs.
 - Example: Use anonymous surveys or feedback forms to collect information about students' accessibility requirements.
- 5. **Implement Universal Design for Learning (UDL):**
 - **UDL Principles:** Apply UDL principles to design accessible learning environments that cater to diverse needs without requiring specific accommodations.
 - Example: Provide materials in multiple formats (e.g., text, audio, video) to ensure all students can access the content.
- 6. **Active Learning with Attention to Equity:**
 - **Inclusive Participation:** Design active learning activities that are accessible and inclusive for all students, considering potential barriers.
 - Example: Use varied group work strategies to ensure that students with different abilities and backgrounds can participate fully.
- 7. **Address Structural Barriers:**
 - **Environmental Considerations:** Evaluate and modify physical and digital environments to remove barriers to access.
 - Example: Ensure that laboratory spaces are navigable for wheelchair users and equipped with necessary adaptive technologies.

Reducing Inequality in Academic Success for Incoming College Students: A Randomized Trial of Growth Mindset and Belonging Interventions

Broda, Michael, John Yun, Barbara Schneider, David S. Yeager, Gregory M. Walton, Matthew Diemer. "Reducing inequality in academic success for incoming college students: A randomized trial of growth mindset and belonging interventions." *Journal of Research on Educational Effectiveness* 11.3 (2018): 317-338.

Keywords

- Light-touch intervention
- Growth mindset
- Social belonging
- Postsecondary education
- Academic outcomes
- Underrepresented students
- Disadvantaged students

Summary

The article investigates the effectiveness of light-touch psychological interventions, specifically growth mindset and social belonging interventions, on the academic success of underrepresented college students. Conducted at a large Midwestern public university, the study involved 7,686 incoming first-year students randomly assigned to either a growth

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mindset intervention, a social belonging intervention, or a control group. The growth mindset intervention significantly improved the GPA of Latino/a students, reducing the GPA gap between White and Latino/a students by 72%. However, the social belonging intervention did not show significant effects on academic outcomes for any student subgroup. The study highlights the potential of minimally invasive interventions to support the academic performance of disadvantaged students while also noting the complexity of implementing customized belonging interventions in diverse educational contexts.

Practical Actions Recommended

Growth Mindset Intervention:

- 1. Implement Educational Modules on Brain Plasticity:**
 - Introduce students to the concept that intelligence can grow with effort and practice.
 - Use short scientific articles and reflective exercises to reinforce the idea of a malleable intelligence.
- 2. Encourage Reflective Writing:**
 - Have students write about personal experiences where they adopted a growth mindset.
 - Ask students to provide advice to future students based on these experiences, reinforcing their understanding.
- 3. Provide Examples of Effort Leading to Success:**
 - Share stories and testimonials from upperclassmen or alumni who achieved success through perseverance and hard work.

Social Belonging Intervention:

- 1. Share Upperclassmen Stories:**
 - Present incoming students with stories from diverse upperclassmen about overcoming initial challenges in college.
 - Ensure stories reflect a range of experiences and backgrounds to resonate with a diverse student body.
- 2. Facilitate Reflective Exercises:**
 - After reading these stories, ask students to reflect on their own feelings and write responses about their expectations and concerns.
 - Encourage students to relate the stories to their personal experiences and consider strategies for overcoming challenges.
- 3. Match Stories to Student Demographics:**
 - Customize the first story a student reads to match their identified gender and race/ethnicity to enhance relatability and impact.

General Recommendations:

- 1. Monitor and Support Implementation:**
 - Ensure the interventions are integrated seamlessly into existing orientation programs without causing additional stress or workload for students.
- 2. Evaluate and Adjust:**

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- Continuously evaluate the effectiveness of these interventions and make necessary adjustments to better fit the specific context and needs of the student population.
- 3. **Foster an Inclusive Environment:**
 - Promote a campus culture that values diversity and inclusivity, supporting students from all backgrounds to feel they belong and can succeed.

Strategies for Integrating Student Supports and Academics

Dadgar, Mina, Thad Nodine, Kathy Reeves Bracco, Andrea Venezia. "Strategies for integrating student supports and academics." *New Directions for Community Colleges* 2014.167 (2014): 41-51.

Keywords

- Student Support Services
- Academic Integration
- Community Colleges
- Student Success
- Academic Advising
- Tutoring
- Career Planning
- Educational Planning

Summary

The article by Dadgar et al. examines strategies for integrating student support services with academic instruction in community colleges to enhance student success. The authors highlight that integrating these services—such as academic advising, tutoring, and career planning—within the classroom setting can improve student outcomes by providing a more cohesive and supportive learning environment. The study discusses various models and strategies implemented by colleges across the nation, including embedding advisors and tutors in classrooms, developing integrated student success centers, and using technology to connect support services with instruction. The article emphasizes that such integration helps expand access to support services, engages students more effectively, and reduces the stigma associated with seeking help.

Practical Actions Recommended

1. **Embedding Support in Departments and Classes**
 - **Embedding Advisors in Departments:** Assign advisors to specific departments to foster familiarity with program requirements and create consistent support for students.
 - *Example:* Valencia College hired advisors for career/technical education programs to provide specialized advising.
 - **Embedding Advisors in Classrooms:** Incorporate advisors into courses, either through paired classes or by bringing career advisors directly into the classroom.
 - *Example:* Santa Barbara City College integrates career advisors into foundational courses to assist with education and career planning.
 - **Embedding Tutors in Classrooms:** Place tutors in high-risk classes or designate time for meeting with tutors outside of class to ensure students

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receive necessary support.

- *Example:* Some developmental education courses include required tutoring sessions as part of class time.

2. Offering Integrated Student Success Centers

- Develop centers that provide a range of coordinated supports integrated with classroom instruction, available to all students.

- *Example:* Chaffey College organizes success centers by academic topic rather than developmental needs, reducing stigma and encouraging all students to seek help.

3. Developing First-Year Experiences

- **Mandatory Orientation and Student Success Courses:** Offer structured support through mandatory orientation and success courses that provide advising, career planning, and study skills.

- *Example:* Valencia College involves developmental education faculty in the assessment process to better prepare students and align support services with classroom instruction.

4. Using Technology to Connect Student Supports and Instruction

- Utilize technology for online orientation, degree planning, and early alert systems to offer individualized support.

- *Example:* Implement technology-based degree audits complemented by in-person advising to ensure students receive comprehensive guidance.

Implementation Recommendations

- **Start with Collaborative Programs:** Begin integration efforts with programs that have a history of collaboration, such as developmental education or first-year experiences.
- **Strengthen Campus Culture of Collaboration:** Involve faculty and staff in planning and decision-making processes to foster a culture of collaboration focused on student success.
- **Use Professional Development Effectively:** Provide extensive training and incentives for faculty and staff to understand their roles in supporting student learning and to deliver consistent, high-quality support services.

Supporting Diverse Learning Styles: A Case Study in Student-Led Syllabus Design

Harding, Lauren Howard. "Supporting Diverse Learning Styles: A Case Study in Student Led Syllabus Design." *Journal of Political Science Education* 19.1 (2023): 83-90.

Keywords

- Syllabus Design
- Negotiated Syllabus
- Student Led
- Learning Styles
- Active Learning

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Summary

The article presents a case study on student-led syllabus design implemented in an Honors American Government course. This approach aimed to accommodate diverse learning styles and increase student engagement. Students were surveyed on their preferred learning methods, assignment types, accountability mechanisms, and levels of active learning. The resultant syllabus incorporated both passive and active learning activities such as lectures, readings, debates, simulations, and group discussions. Student feedback indicated high satisfaction with the course, demonstrating enhanced motivation and engagement due to their involvement in the syllabus design process. The study concludes that student-led syllabus design can effectively address diverse learning preferences and promote a more engaging and inclusive learning environment.

Practical Actions Recommended

- 1. Conduct Surveys to Determine Learning Preferences:**
 - Use surveys to gather information on students' preferred learning methods, assignment types, and accountability mechanisms.
 - Example: On the first day of class, distribute a survey asking students to rank their preferences for lectures, readings, group discussions, debates, and simulations.
- 2. Incorporate a Mix of Learning Activities:**
 - Design a syllabus that balances traditional and active learning methods to cater to different learning styles.
 - Example: Include lectures and readings for those who prefer reflective learning and simulations and debates for those who prefer active learning.
- 3. Adapt Assignments to Accommodate Diverse Learning Styles:**
 - Modify assignments to ensure all students can engage in a manner that suits their learning preferences.
 - Example: For a debate assignment, allow some students to participate actively while others contribute through research and analysis.
- 4. Promote Student Ownership and Responsibility:**
 - Involve students in the decision-making process to enhance their sense of ownership and responsibility for their learning.
 - Example: Allow students to select topics for current events discussions and choose their roles in group projects.
- 5. Foster Continuous Feedback and Adaptation:**
 - Create an environment where students feel comfortable providing feedback and suggest adjustments throughout the course.
 - Example: Regularly ask for student input on the effectiveness of different activities and make necessary adjustments based on their feedback.
- 6. Balance Student Choices with Essential Content:**
 - Ensure that while students have input in the syllabus design, the core content and skills necessary for the course are not compromised.
 - Example: Maintain essential topics and skills in the syllabus while allowing flexibility in the methods used to teach these elements.
- 7. Evaluate and Reflect on the Approach:**

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- Assess the impact of student-led syllabus design on learning outcomes and student satisfaction to refine the approach for future courses.
- Example: Use pre-test and post-test evaluations to measure learning gains and gather detailed student feedback on the syllabus design process.

Internationalization, English L2 Writers, and the Writing Classroom: Implications for Teaching and Learning

Zawacki, T. M., & Habib, A. S. (2014). Internationalization, English L2 Writers, and the Writing Classroom: Implications for Teaching and Learning. *College Composition and Communication*, 65(4), 650-658. National Council of Teachers of English.

Keywords

- Internationalization
- English L2 writers
- writing instruction
- multilingual students
- second language writing
- academic writing
- Translingualism
- linguistic diversity

Summary

The article by Zawacki and Habib addresses the implications of internationalization for English L2 (second language) writers in the college writing classroom. The authors explore the challenges faced by multilingual students as they navigate differing linguistic, cultural, and academic expectations. Drawing from their research and interviews with international students, the authors highlight the need for writing instructors to focus explicitly on language as a rhetorical tool and consider the diverse linguistic backgrounds of their students. The article argues for a translingual approach to writing instruction, emphasizing the value of integrating students' multilingual experiences into their academic writing processes. By doing so, educators can better support the development of academic writing competence across diverse contexts.

Practical Actions Recommended

- 1. Explicit Language Instruction:**
 - Integrate explicit grammar instruction and metalinguistic commentary to help students develop fluency and accuracy in academic writing.
 - Example: Provide lessons on specific grammatical structures and usage in the context of academic writing tasks.
- 2. Contextualized Writing Practice:**
 - Design writing tasks that reflect real-world academic and professional contexts, helping students apply language skills in meaningful ways.

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- Example: Create assignments that simulate professional communication scenarios, such as writing reports or presentations.
- 3. **Translingual Pedagogy:**
 - Encourage students to draw on their linguistic resources and experiences, fostering a classroom environment that values multilingualism.
 - Example: Allow students to use their first language for brainstorming or drafting before translating their ideas into English.
- 4. **Rhetorical Awareness:**
 - Teach students to understand and adapt to different rhetorical expectations and conventions across linguistic and cultural contexts.
 - Example: Discuss how rhetorical strategies may vary between English and students' home languages, and how to navigate these differences.
- 5. **Student-Centered Feedback:**
 - Provide individualized feedback that addresses both language development and rhetorical effectiveness, supporting students' growth as writers.
 - Example: Offer targeted comments on students' drafts that highlight areas for improvement in both language and argumentation.
- 6. **Cultural and Linguistic Inclusivity:**
 - Foster an inclusive classroom atmosphere that respects and integrates students' cultural and linguistic backgrounds.
 - Example: Use diverse examples and materials that reflect the global nature of academic writing and scholarship.
- 7. **Collaborative Learning:**
 - Implement collaborative activities that allow students to share their linguistic and cultural insights, enhancing peer learning.
 - Example: Organize group projects where students work together to analyze and critique texts from different linguistic perspectives.

Multi-view Protocols: Visualizing the Macro and the Micro of a Laboratory Method

Sandwith, S. N., Reisinger, M. A., Schmidt, E. S., Saunders, D. W., Richardson, A. E., Chambers, A. E., Smaldino, M. A., & Smaldino, P. J. (2020). Multi-view Protocols: Visualizing the Macro and the Micro of a Laboratory Method. *The American Biology Teacher*, 82(9), 624-627.
doi:10.1525/abt.2020.82.9.624

Keywords

- Multi-view protocols (MVPs)
- laboratory teaching
- procedural learning
- theoretical learning
- inquiry-driven learning
- visual aids
- biology education

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Summary

The article introduces Multi-view Protocols (MVPs), an innovative teaching tool designed to enhance the learning experience in laboratory settings by integrating textual instructions, photographic depictions, and theoretical illustrations. MVPs address three key questions students often have when learning new laboratory techniques: what to do, where and how to do it, and why each step is important. By providing detailed textual steps, visual images of the protocol in action, and illustrations of molecular processes, MVPs help students understand both the procedural and theoretical aspects of laboratory methods. The authors suggest that MVPs improve comprehension, reduce errors, and facilitate smoother transitions for new students in both research and teaching labs. MVPs are adaptable for different educational levels, from high school to undergraduate courses, and can be tailored for various laboratory protocols.

Practical Actions Recommended

1. Textual Protocol:

- Provide detailed step-by-step instructions including reagent names, volumes, concentrations, and incubation times.
- Example: Include clear instructions for each step of a chromatin immunoprecipitation (ChIP) protocol, specifying the exact reagents and volumes required.

2. Photographic Protocol:

- Use photographs to visually depict the protocol being performed in the laboratory space, showing exact locations and actions.
- Example: Include images showing the correct pipetting technique and placement of samples in a centrifuge during a trypsinization reaction with HeLa cells.

3. Theoretical Illustrations:

- Incorporate illustrations that explain the molecular details and theoretical principles behind each step of the protocol.
- Example: Provide diagrams illustrating the interaction between antibodies and chromatin during the ChIP process.

4. Student Engagement:

- Encourage students to create the theoretical illustration column themselves to enhance their understanding of the molecular principles.
- Example: Assign students to draw and annotate the steps of proteinase K digestion, explaining the enzymatic action at the molecular level.

5. Pre-lab Assignments:

- Use MVPs as pre-lab assignments to identify and address students' misconceptions before they perform the experiments.
- Example: Have students complete the theoretical illustration column as homework and review their drawings to clarify any misunderstandings.

6. Assessment and Feedback:

- Utilize MVPs to assess students' understanding and provide personalized feedback based on their drawings and explanations.

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- Example: Review students' completed MVPs for a PCR protocol to ensure they understand the function of each enzyme involved and the rationale behind the steps.
- 7. Adaptation and Scalability:**
- Tailor MVPs to fit various experimental designs and educational levels, making them a versatile tool for different teaching contexts.
 - Example: Modify MVPs for advanced placement (AP) biology labs, focusing on the key concepts that will be tested in the AP exams.

Tactile Trees: Demystifying Phylogenies for Everyone with Universal Design for Learning

Hasley, A. O., Jenkins, K. P., Orndorf, H., & Gibson, J. P. (2024). Tactile Trees: Demystifying Phylogenies for Everyone with Universal Design for Learning. *The American Biology Teacher*, 86(5), 281-288. doi:10.1525/abt.2024.86.5.281

Keywords

- Universal Design for Learning
- tree thinking
- Phylogeny
- evolution
- tactile learning
- inclusive education
- biology teaching

Summary

The article presents a Universal Design for Learning (UDL) approach to teaching phylogenetic tree thinking, addressing both cognitive and physical barriers faced by students, including those who are blind or low-vision. The authors modified the Great Clade Race (GCR) activity into a tactile version to enhance accessibility. The tactile adaptation retains the educational goals of the original activity while making it inclusive. By using yarn and felt to represent evolutionary lineages and check-in stations, the tactile version allows students to engage with the material physically and visually. The study found that students using the tactile version demonstrated improved engagement, reduced confusion, and increased collaboration compared to those using the traditional visual version. This UDL-aligned approach facilitated deeper understanding of evolutionary concepts and enhanced overall learning experiences.

Practical Actions Recommended

- 1. Utilize Tactile Learning Tools:**
 - **Tactile Phylogenetic Trees:** Use yarn and felt to create tactile phylogenetic trees that students can physically manipulate.

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- Example: Students use yarn strands tied together to represent evolutionary lineages, adding tactile tokens to indicate traits and evolutionary branches.
- 2. **Inclusive Educational Activities:**
 - **Adapt Traditional Activities:** Modify existing activities like the Great Clade Race to include tactile and visual elements, making them accessible to all students.
 - Example: Replace visual symbols with distinct tactile objects to indicate different evolutionary traits.
- 3. **Encourage Group Collaboration:**
 - **Group Work:** Foster collaboration by having students work together on tactile tree-building activities.
 - Example: Assign groups to create phylogenetic trees and discuss their findings, promoting peer learning and reducing individual frustration.
- 4. **Reduce Cognitive Load:**
 - **Simplify Initial Tasks:** Start with a basic framework of phylogenetic trees to help students focus on understanding evolutionary relationships without being overwhelmed.
 - Example: Provide a common starting point and simple rules for constructing trees to guide students through the activity.
- 5. **Incorporate Multisensory Engagement:**
 - **Multiple Modes of Representation:** Use both tactile and visual elements to engage different senses and reinforce learning.
 - Example: Combine visual diagrams with tactile models to cater to diverse learning preferences and needs.
- 6. **Provide Clear Instructions and Feedback:**
 - **Step-by-Step Guidance:** Offer detailed instructions and immediate feedback to support student understanding and correct misconceptions.
 - Example: Use clear, incremental steps to guide students through the activity and provide opportunities for self-assessment and reflection.
- 7. **Focus on Conceptual Understanding:**
 - **Emphasize Key Concepts:** Ensure that activities help students grasp fundamental evolutionary concepts and relationships.
 - Example: After constructing the tree, discuss the evolutionary significance of traits and common ancestors to reinforce learning.