This is a pre-print version of a table included in the following article: Shortlidge, E., Jolley, A., Shaulskiy, S., Ward, E. G., Lorentz, C., & O'Connell, K. (2021). A Resource for Understanding and Evaluating Outcomes of Undergraduate Field Experiences. *Ecology and Evolution*, *Preprint*. https://doi.org/10.22541/au.162552645.55884431/v1

Table 1. The intended student outcomes were first identified from the UFERN landscape study (O'Connell et al. 2020) and by participants at the 2018 UFERN Network Meeting at Kellogg Biological Station, April 30 – May 2, 2018. The authors of this essay then refined the list by removing those outcomes that were either duplicated, irrelevant, not measurable, or linked to very specific contexts (not field universal). Each outcome is grouped according to a primary aim defined in the table below. The table organizes published assessment instruments that fall under each primary aim category and that are applicable for use in undergraduate field education experiences. This table was designed to help practioners identify assessment instruments that align with the intended student outcomes they have identified for their field experiences. The primary aims are categories that the authors have defined to link outcomes with assessments using language that is accessible to the practitioner. The aim categories do not necessarily represent specific constructs or scales for individual assessments. The structure of the table follows that designed by Shortlidge and Brownell (2016).

Primary Aim	Example Student Outcomes	Example Assessment Instruments for Measuring Aim	Measurement details (# of items, item type, time to administer)	Population(s) tested	Ease of Analysis	Original Reference
Broader Relevance - ***development of awareness and connection beyond the context of the field experience***	• Increased sense of connection to local/community problems or issues • Increased sense of connection to large-scale problems or issues • Development as informed citizens	**Perceived Cohesion Scale (PCS)**	6 items, Likert	Multiple ages & populations	Easy	Bollen, K. A., and R. H. Hoyle. 1990. Perceived cohesion: a conceptual and empirical examination. Soc. Forces 69(2):479–504.
Connection to Place - ***relationships between people***	• Increased stewardship intention or behaviors	**Environmental Orientations (ECO)**	16 items, Likert	Ages 6 – 13	Easy	Larson, L. R., Green, G. T., & Castleberry, S. B. (2011). Construction and Validation of an Instrument to Measure Environmental Orientations in a Diverse Group of Children. Environment and Behavior, 43(1),

and the field environment	• Increased respect or care for the environment • Stronger connections to place					72–89. https://doi.org/10.1177/0013916509345212
		Environmental Attitudes Inventory (EAI)	24 or 72 items, Likert	Multiple ages & populations	Easy	Milfont, T.L., and J. Duckitt. (2010). The environmental attitudes inventory: a valid and reliable measure to assess the structure of enviornmental attitudes. J. Envrion. Psychol. 30: 80-94.
		Place Attachment Inventory (PAI)	15 items, Likert	Multiple ages & populations	Easy	Williams, D.R., and Vaske, J.J., 2003, The measurement of place attachment: validity and generalizability of a psychometric approach: Forest Science, v. 49, p. 830-840.
		Place Meaning Questionnaire (PMQ)	30 items, Likert	Multiple ages & populations	Easy	Young, M., 1999, The social construction of tourist places: Australian Geographer, v. 30, p. 373-389, doi:10.1080/00049189993648.
		Place Meaning Scale-Marine Environments (PMS-ME)	34 items, Likert	Tourist industry representatives; resource managers; and recreational visitors	Easy	Wynveen, C. J., & Kyle, G. T. (2015). A place meaning scale for tropical marine settings. Environmental management, 55(1), 128-142.
		New Ecological Paradigm Scale (NEP)	15 items, Likert	Multiple ages & populations	Easy	Dunlap, R., K. Liere, A. Mertig, and R.E. Jones. 2000. Measuring endorsement of the new ecological paradigm: a revised NEP scale. J. Soc. Iss. 56: 425-442.
Nature of Science - ***Understanding of the process of science and how scientific knowledge is generated***	• Increased awareness of scientific ethics • Stronger sense of what life as a scientist is like • Increased knowledge of the nature of science	**Colorado learning attitudes about science survey - biology (CLASS-Bio)**	31 items, Likert	Undergraduate students (University of Colorado and University of British Columbia)	Moderate	Semsar, K., Knight, J.K., Birol, G., and Smith, M.K. (2011). The Colorado Learning Attitudes about Science Survey (CLASS) for use in biology. CBE-Life Sciences Education, 10, 268-278.
		Views on the Nature of	Open-ended, 45-60 minutes	Multiple ages & populations	Hard (requires inter-	Lederman, N. G., F. Abd-El-Khalick, R. L. Bell, and R. S. Schwartz. 2002. Views of nature of science questionnaire: toward

	• Increased proficiency in general research practices	**Science (VNOS-C)**			rater review of answers)	valid and meaningful assessment of learners' conceptions of nature of science. J. Res. Sci. Teach. 39:497–521.
		Biological Experimental Design Concept Inventory (BEDCI)	14 items, multiple choice, 18 minutes	Undergraduate students (University of British Columbia)	Easy	Deane, T., K. Nomme, E. Jeffery, C. Pollock, and G. Birol. 2014. Development of the biological experimental design concept inventory (BEDCI). CBE Life Sci. Educ. 13:540–551.
		Expanded Experimental Design Ability Test (E-EDAT)	Open-ended	Undergraduate students (University of Washington)	Moderate (Rubric)	S. E. Brownell, M.P. Wenderoth, R. Theobald, N. Okoroafor, M. Koval, S.Freeman, C. L. Walcher-Chevillet, A.J. Crowe, How Students Think about Experimental Design: Novel Conceptions Revealed by in-Class Activities, BioScience, Volume 64, Issue 2, February 2014, Pages 125–137, https://doi.org/10.1093/biosci/bit016
		Experimental Design Ability Test (EDAT)	Open-ended, 10-12 minutes	Undergraduate students, Introductory class (Bowling Green State)	Moderate (Rubric)	Sirum, K., and J. Humburg. 2011. The experimental design ability test (EDAT). Bioscene J. Coll. Biol. Teach. 37:8–16
		The Rubric for Science Writing	Open ended	Undergraduates students and Graduate teaching assistants (University of Southern California)	Moderate (Rubric)	Timmerman, B. E C., D. C. Strickland, R.L. Johnson, and J. R. Payne. 2011. Development of a 'universal' rubric for assessing undergraduates' scientific reasoning skills using scientific writing. Assess. Eval. Higher Educ. 36:509–547.
		Test of Scientific Literacy Skills (TOSLS)	Multiple Choice, 30 minutes	Multiple populations	Easy	Gormally, C., P. Brickman, and M. Lutz. 2012. Developing a test of scientific literacy skills (TOSLS): measuring undergraduates' evaluation of scientific information

						and arguments. CBE Life Sci. Educ. 11:364–377.
		Student perceptions about earth science survey (SPESS)	29 items, Likert	Undergraduate students in earth and ocean sciences (University of British Columbia)	Moderate	Jolley, A., Lane, E., Kennedy, B., and Frappé-Sénéclauze, T. 2012. SPESS: a new instrument for measuring student perceptions in earth and ocean science. Journal of Geoscience Education, 60(1):83-91.
		Entering Research Learning Assessment (ERLA)	53 items, with 47 item optional paired assessment for mentors to assess trainee gains	Multiple populations of undergraduate and graduate trainees	Moderate (scoring guide)	Butz, A. R., & Branchaw, J. L. (2020). Entering Research Learning Assessment (ERLA): Validity evidence for an instrument to measure undergraduate and graduate research trainee development. CBE – Life Sciences Education, 19(2) https://doi.org/10.1187/cbe.19-07-0146
		Views about Science Survey (VASS)	30 items, Likert	8th-undergraduate students	Easy	Halloun, Ibrahim. (2001). Student Views about Science: A Comparative Survey. Beirut: Phoenix Series / Educational Research Center, Lebanese University.
Personal Gains - ***cognitive (e.g. content knowledge), behavioral (e.g. skills), and affective characteristics (e.g. comfort, confidence, self-efficacy) gained***	• Ability to live and work in primitive or adverse camping conditions • Development of or increased "Grit" (perseverance through tough situation)	**Grit Scale (GRIT)**	8 or 12 items, Likert	Multiple populations	Easy	Duckworth, A. L., Peterson, C., Matthews, M. D., & Kelly, D. R. (2007). Grit: Perseverance and passion for long-term goals. Journal of Personality and Social Psychology, 92(6), 1087-1101.
		Climate change concept inventory	21 items, Likert	Undergraduate students	Easy	Libarkin, J. C., Gold, A. U., Harris, S. E., McNeal, K. S., & Bowles, R. P. (2018). A new, valid measure of climate change understanding: associations with risk perception. Climatic Change, 150(3-4), 403-416.
		Geoscience concept inventory (GCI)	select 15 question subset from	Undergraduate students	Easy	Libarkin, J.C., Anderson, S.W., (2006). The Geoscience Concept Inventory: Application of Rasch Analysis to Concept Inventory

through field experience	• Increased content knowledge • Increased interest in the topic of field course • More refined career goals • Improved discipline-specific skills • Development of outdoor skills • Increased confidence in physical fitness		73 total questions, Multiple choice			Development in Higher Education: in Applications of Rasch Measurement in Science Education, ed. X. Liu and W. Boone: JAM Publishers, p. 45-73
		National Survey of Student Engagement (NSSE)*	70 items, Likert	Multiple populations	Easy	Kuh, G. D. 2009. The national survey of student engagement: conceptual and empirical foundations. New Direct. Inst. Res. 2009:5–20.
		Landscape identification and formation timescales (LIFT)	12 items, Multiple choice	Undergraduate students in earth and ocean sciences (University of British Columbia)	Easy	Jolley, A., Jones, F., and Harris, S. 2013. Measuring student knowledge of landscapes and their formation timespans. Journal of Geoscience Education, 61(2):240-251.
		Psychological Sense of School Membership (Class Belonging/School Belonging)	18 items, Likert	Middle school and undergraduate students	Easy	Goodenow, C. (1993). The psychological sense of school membership among adolescents: Scale development and educational correlates. Psychology in the Schools, 30, 79-90.
Personal Connections to Science Context - *affective characteristics such as comfort, confidence, self-efficacy in science more broadly*	• Greater sense of belonging in the scientific community • Increased value for the interdisciplinary nature of science • Increased interest in a general science career	**Common Instrument Suite (CIS)***	10 items, Likert	Grades 4 and above	Easy	https://www.thepearinstitute.org/common-instrument-suite
		Motivated strategies for learning questionnaire (MSLQ)	81 statements, Likert		Easy	Pintrich, R. R., & DeGroot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance, Journal of Educational Psychology, 82, 33-40.
		Science Interest Survey (SIS)	21 items, Likert	Middle and high school grade children from varying ethnic backgrounds	Easy	Lamb, R.L., Annetta, L., Meldrum, J. et al. MEASURING SCIENCE INTEREST: RASCH VALIDATION OF THE SCIENCE INTEREST SURVEY. Int J of

	• Increased interest in a field-based science career • Increased scientific self-efficacy					Sci and Math Educ 10, 643–668 (2012). https://doi.org/10.1007/s10763-011-9314-z
		Career Decision Making Survey - Self Authorship (CDMS-SA)	18 items, Likert	Multiple populations	Easy	Creamer, E. G., M. B. Magolda, and J. Yue. 2010. Preliminary evidence of the reliability and validity of a quantitative measure of self-authorship. J. Coll. Student Devt. 51:550–562
		Research on the Integrated Science Curriculum (RISC)	Likert, adaptable		Easy	https://www.grinnell.edu/academics/centers-programs/ctla/assessment/risc
		Student Assessment of Learning Gains (SALG)	5 item, Likert	College students (CSU-Fullerton)	Easy	Student Perspectives on Curricular Change: Lessons from an Undergraduate Lower-Division Biology Core Merri Lynn Casem CBE—Life Sciences Education 2006 5:1, 65-75
		Science Motivation Questionnaire II (SMQII)	25 item, Likert	College students (University of Georgia)	Easy	Glynn, S. M., P. Brickman, N. Armstrong, and G. Taasoobshirazi. 2011. Science motivation questionnaire II: validation with science majors and nonscience majors. J. Res. Sci. Teach. 48:1159–1176.
		Survey of Undergraduate Research Experiences (SURE)	15 minute, Likert		Easy	Lopatto, D. 2004. Survey of undergraduate research experiences (SURE): first findings. Cell Biol. Educ. 3:270–277.
		Undergraduate Student Self-Assessment Instrument (URSSA)	Likert, adaptable	Multiple undergraduates - geared towards URE but mostly applicable	Easy	The Undergraduate Research Student Self-Assessment (URSSA): Validation for Use in Program Evaluation Timothy J. Weston and Sandra L. Laursen CBE—Life Sciences Education 2015 14:3

		STEM Self-efficacy (STEM-SE)	29 items including demographic questions, Likert	Undergraduate students but with emphasis on historically underrepresented racial/ethnic groups in science majors engaged in research experiences	Easy	Byars-Winston A, Rogers J, Branchaw J, Pribbenow, Hanke R, Pfund C. (2016). New measures assessing predictors of academic persistence for historically underrepresented racial/ethnic undergraduates in science. CBE Life Sciences Education, 3ar32.
		STEM Career Interest Survey (STEM-CIS)	44 items, Likert	Middle school students (grades 6–8) who primarily were in rural, high-poverty districts in the southeastern USA	Easy	Kier M, Blanchard M, Osborne J, Albert J. (2014). The development of the STEM career interest survey (STEM-CIS). Research in Science Education 44:461-481.
Transferable Skills - *skills that can be applied to contexts outside of science*	• Improved communication skills • Improved collaboration skills • Improved problem-solving skills • Improved critical thinking skills	**Critical Thinking Assessment Test (CAT)***	15 items, Open-ended	Multiple populations	Moderate (scoring guide)	Stein, B., A. Haynes, M. Redding, T. Ennis, and M.Cecil. (2007). Assessing critical thinking in STEM and beyond, p 79–82. In: Innovations in e-learning, instruction technology, assessment, and engineering education. Springer, Netherlands
		California Critical Thinking Skills Test (CCTST)*	45 minutes, Multiple choice	Undergraduate students (CSU Fullerton)	Easy	Facione, P. A. 1991. Using the California Critical Thinking Skills Test in Research, Evaluation, and Assessment. [Online.]

		Self-perceived communication competence (SPCC)	12 items, Numerical rating on 100 point scale	Undergraduate students	Easy	McCroskey, J.C., & McCroskey, L. L. (1988). Self-report as an approach to measuring communication competence. Communication Research Reports, 5(2), 108-113.