Closing the academia to industry skills gap in undergraduate environmental science using curriculum-to-careers programmatic mapping

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Problem/Background

The period from 2010 to 2020 has been turbulent for managers in the workplace. Seventy-seven million people in the Baby Boom generation, the cohort of the workforce born between 1946 to 1964, were retiring towards the end of 2010 (Crutsinger, 2004). Based on workforce projections, retirements would place Social Security and Medicare at risk, but earlier studies did not account for the additional disruption to the workforce that resulted from the loss of the Baby Boom generation's knowledge and skills (Kessler, 2014; Marketwired, 2015). For over a decade, institutions have coped with a pace of employee attrition of 10,000 individuals a day with that trend projected to continue through the next decade (Kessler, 2014; Marketwired, 2015).

Employee loss and labor turnover increased during the global pandemic of 2020. As a result, all sectors experienced workforce attrition termed the "Great Resignation." Factors that influence employees exiting the workforce are partially associated with the coronavirus disease (COVID-19) as some workers, whether due to age or health conditions, experience health insecurity (Prior, 2022). Other issues around employee attrition stem from low morale, lack of opportunity for career advancement within institutions, compensation, and flexibility (American Banker Magazine, 2022; Ewen, 2022; Beckwin, 2018). Combined, these issues result in the paucity of workforce availability experienced across multiple industries.

Reduction in employee interest and activity is documented in the Federal Reserve's "Beige Book," a report generated 8 times a year to track the United States' workforce trends and economic activity. Recent trends include businesses and institutions having difficulty hiring new workers (Jacobson, 2021). A decrease in skilled workers places pressure on business and erodes output and hours of operation. The Federal Reserve has stated, "a variety of indicators suggest labor demand remains strong, while labor supply remains below pre-pandemic conditions." (Brainard, 2022), and further reports conclude that businesses are triaging the situation with incentives to retain and maintain the workforce they have.

The Central Ohio College and Career Readiness explored cross-sector partnerships between education and industry to examine college-to-career pathways. Colleges engaged employers "as co-designers and decision-makers" to create pathways via internships or collaboration (Hooker, Acevedo, & Dow, 2021). Looking outside the institution to prepare students for careers was their way of creating a "meaningful systems change" to align education to career paths. However, their steps to build career readiness within their curriculum are less clear. The collaborative model retains employer engagement; however, it does not address how students become career-ready before graduation within the construct of the college or university system. The throughline that connects the student to industry is not accounted for within the curriculum.

Education institutions must acknowledge that students come to environmental education with their own experiences and potentially little knowledge of the industry. Students may have some conceptual knowledge and understanding of environmental systems and human communities' influence on those systems; however, that understanding may be insufficient to connect traditional environmental science concepts to environmental industry careers. This paper aims to outline the steps taken by one large, online institution of higher education, serving non-traditional adult learners, to better prepare students for the environmental science workforce by bridging the college-to-career gap between academics and industry.

The College-to-Career Gap

Institutions of higher education require means to assess their effectiveness of teaching students foundational knowledge. Adopting a comprehensive assessment strategy is a challenge for the stakeholders responsible for creating and deploying postsecondary degree programs (Bevitt, 2015; Jamieson, Jenkins, Beatty, & Palermo, 2017; King, Schuwirth, & Jordaan, 2022). Organizations like the Higher Learning Commission (Higher Learning Commission, 2022) and the America Association of Colleges and Universities (American Association of Colleges and Universities, 2022) offer professional development in this area. One common assessment strategy is to create program maps.

To create a programmatic map, it is necessary to develop program student learning outcomes (PSLOs) and course student learning outcomes (CSLOs). Course student learning outcomes must be aligned to program student learning outcomes. As students progress through courses in the program, the level of cognitive rigor and conceptual understanding should deepen and be reflected in the CSLOs in each course. Summative assessments can be created to assess student achievement of each CSLO. These summative assessments should elicit student knowledge at the appropriate level of cognitive rigor, as defined by the program map. Student performance on the summative assessments imply the level of student comprehension of CSLOs and the associated PSLOs. These performance metrics can serve as indicators of how effective course design and classroom experience are in supporting students to achieve competency in both course and program learning outcomes. The process of programmatic outcomes mapping is complex. It requires engaging subject matter, learning theory, assessment, and teaching expertise. Given these complexities, many institutions have challenges developing maps and deploying a comprehensive and robust assessment strategy.

Businesses frequently require graduates from institutions of higher education to supply their workforce. Ideal employees will have the necessary content knowledge and applicable career skills to successfully contribute to the workforce. Employer-sought skills are often apparent in published job postings and organization-specific professional development opportunities. These skills can be fluid and correspond to the ever-changing needs of the workforce. However, employer-sought skills are not always communicated directly to higher education institutions, and as a result, may not be considered during programmatic mapping. Programmatic mapping is often a complex, rigid process that inhibits the ability of programs to evolve at a rate of change similar to that in industry and the developing workforce needs. Consequently, the gap between institutions of higher education and business industry widens. Over time, if programs do not update their maps, the distance between what colleges teach and what industry needs becomes a chasm that is the college-to-career gap for students.

To address the college-to-career gap, an education-informed program map must integrate skills to become a skill-informed program map that informs the creation of a curriculum-to-careers programmatic map. This paper describes the process of developing a curriculum-to-careers programmatic map for an asynchronous, online higher education institution that serves non-traditional adult learners for an undergraduate environmental science program.

Creating the Curriculum-to-Careers Programmatic Map

Creating the curriculum-to-careers programmatic map requires synthesis of both foundational curricular content knowledge and employer-sought skills. First, to ensure the needs of industry are represented in a degree program, for both foundational curricular knowledge and sought skills, a communication mechanism and feedback loop between industry and institutions of higher education is established. Second, an education-informed map is developed using best practices from assessment frameworks. Third, skills required by industry are collected, consolidated, and organized to develop a skills program map. Fourth, the curriculum and skills maps are synthesized to develop a curriculum-to-careers programmatic map. Finally, the map undergoes changes based on iterative feedback cycles informed by the communication mechanism established earlier between industry and the institution of higher education. The following sections outline this process, refined for the undergraduate environmental science degree.

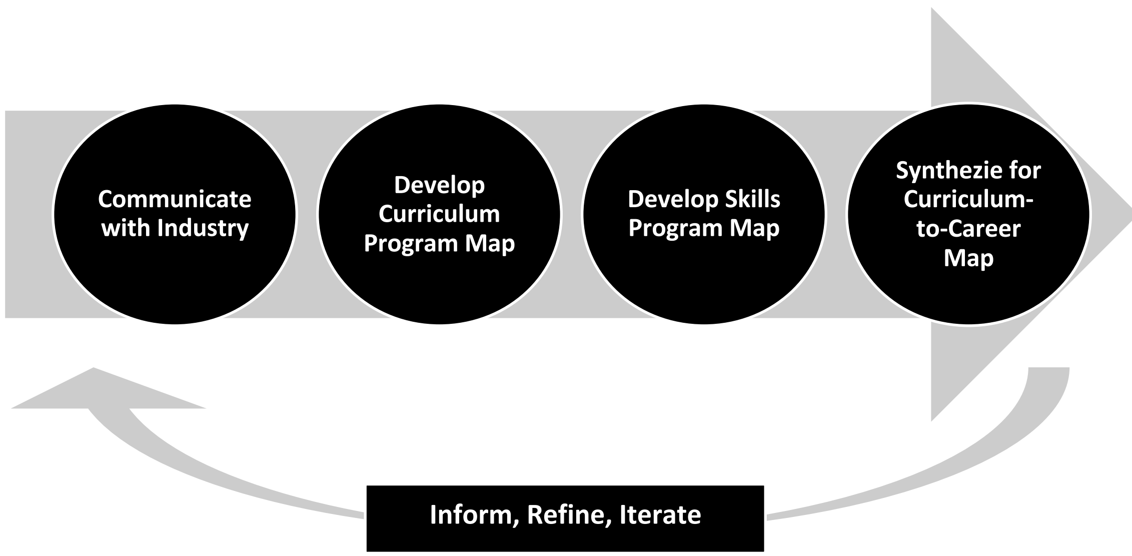

Figure 1. Curriculum-to-Careers Programmatic Map Development Process

1. Communicating with Industry through Advisory Councils

There were 2 approaches to identifying necessary skills to inform the skills mapping component to the programmatic map. Using a refined exploration and examination of job analytic reports, the College first performed a needs-analysis of critical skills required for various career pathways at institutions and businesses. The analysis allowed identification of trends in current job postings aligned to the field of environmental science. The resulting list indicated the most prevalent technical skills, common skills, and software skills in job postings for graduates of bachelor's programs in environmental science or related fields.

To gain insights about relevant skills, the College created an Industry Advisory Council (IAC) by recruiting practitioners in the various industries relevant to the environmental science program. After IAC members were recruited, clear outcomes were established for the IAC. Trends gleaned from the job analytics reports were shared with the IAC and the College gathered qualitative anecdotes from the IAC, which were consistent with quantified patterns observed in the reported industries. This communication mechanism process continues in an iterative cycle to update the programmatic map.

The IAC requires representation from diverse fields throughout the environmental science industry to ensure that broad knowledge is represented in the synthesized map. The selection of one professional leader with tenure from each of the following fields contributed to the council: environmental research science, environmental public policy, applied environmental engineering, and environmental industry. Trends in local regions influenced the selection of organizations considered to characterize labor markets for these areas. To determine which organizations might be helpful, surveys of the local region identified subject matter experts from multiple industries, which informed the council. These subject matter experts were drawn from a local utility agency, the state executive office, a local civil engineering firm, and one of the largest environmental industry organizations within the state. Networking with these prospective members occurred through contact via email and social networking platforms. Invitations to join the IAC outlined the expectations and goals for members. Expectations included attendance to at least 2 annual IAC meetings per year (conducted virtually with a duration of approximately 2 hours each), willingness to share their names and professional affiliations as members of the IAC, availability to respond to questions and to provide feedback for programmatic guidance, and potential for participation in video creation to support classroom curriculum. Four members agreed to participate in the IAC, and each was a representative of the targeted areas of expertise.

The inaugural IAC meeting identified 2 overarching goals:

1) By establishing guidelines for authentic and honest feedback, it is possible to information that addresses the gap between college and industry for students and informs updates to the environmental science program. Guidelines for feedback expectations included that members maintain openness to feedback of any sort (positive, neutral, or negative), and that the focus of the feedback should maximize service to the student as the central goal. At every subsequent IAC meeting, specific program and course items were presented to the industry experts for their additional input for planning and development purposes. Themes emerged from the conversations between program representatives and industry experts and the categorization of these allowed program representatives to identify key lessons to inform program goals.

2) Lessons inferred from council discussion allowed program mapping teams to delineate specific actionable curricular and programmatic improvements to deploy in courses. A continuation of these communication cycles and feedback loops created an iterative cycle for program evolution. IAC members' reflections included feelings of validation as they found evidence of their feedback being used to inform changes within the program in course assignments, resources, and tools that shaped course discussions, deliverables and other classroom experiences.

2. Developing the Curriculum Program Map

After eliciting industry trends, the traditional knowledge associated with the discipline of environmental science was considered. This included the knowledge and information required for students to demonstrate proficiency in the field of environmental science. Programmatic Student Learning Outcomes (PSLOs) were developed from the traditional knowledge associated with a discipline (Mishra, Anbar, Scragg, & Ragan, 2019). Traditional knowledge is the core content knowledge required to be successful in a field. For the field of environmental science, traditional knowledge is rooted in interdisciplinary sciences, application of those sciences to environmental health, and an understanding of complex social structures responsible for environmental policy and regulation. Five PLSOs were developed for the environmental science program to describe what graduates should be able to do: PSLO 1: Develop knowledge that is foundational to the physical and biological sciences; PSLO 2: Evaluate environmental phenomena using social, environmental, and financial principles; PSLO 3: Construct scientific arguments to accurately assess environmental risk; PSLO 4: Utilize environmental regulation to examine human activity; and PSLO 5: Apply environmental policy in the management of the environment. Feedback about the relevance and alignment of these PSLOs was obtained from the IAC, and members validated these outcomes.

Once PSLOs were determined, the course sequence for students was considered. Finalizing the course sequence allowed the College to establish the appropriate level of rigor associated with knowledge and outcomes in each course. Courses early in the sequence were aligned to lower-level outcomes. Subsequent courses were assigned increasing levels of cognitive rigor such that student depth of knowledge and rigor increased through the sequence of courses in the program. These cognitive levels of rigor are identified in the programmatic map as Introduce, Reinforce, and Demonstrate.

After levels of rigor were defined, Course Student Learning Outcomes (CSLOs) were determined for each course. Each CSLO was aligned to a PSLO at the appropriate level of rigor, so assessment of students learning at the course level, for each CSLO, could be used to infer proficiency in a particular PSLO. Once established, this hierarchical approach to knowledge throughout the program provides mechanisms to observe and analyze progression of student learning and performance in the context of each CSLO and PSLO. Feedback related to CSLOs and levels of academic rigor associated with course content and resources was solicited from and validated by programmatic faculty and the IAC.

Figure 2 shows the Curriculum Program Map. The 5 PSLOs are featured. CSLOs were aligned to each PSLO in the order or level of rigor determined by the course sequence. Using PSLO 4 as an example, concepts are first introduced for PSLO 4 in the second CSLO of the sixth course (CSLO 6.2). Students have opportunities to reinforce concepts from PSLO 4 (increase the level of cognitive rigor) in courses fourteen and fifteen (CSLOs 14.1, 14.2, 14.3, 15.1, and 15.2). Concepts are presented in their peak level of rigor, and students demonstrate knowledge of the PSLO in courses fifteen and sixteen (CSLOs 15.3, 16.1, 16.2, and 16.3). Data from assessments of each of the CSLOs provide information about student knowledge with respect to PSLO 4 and at 3 varying levels of cognitive rigor.

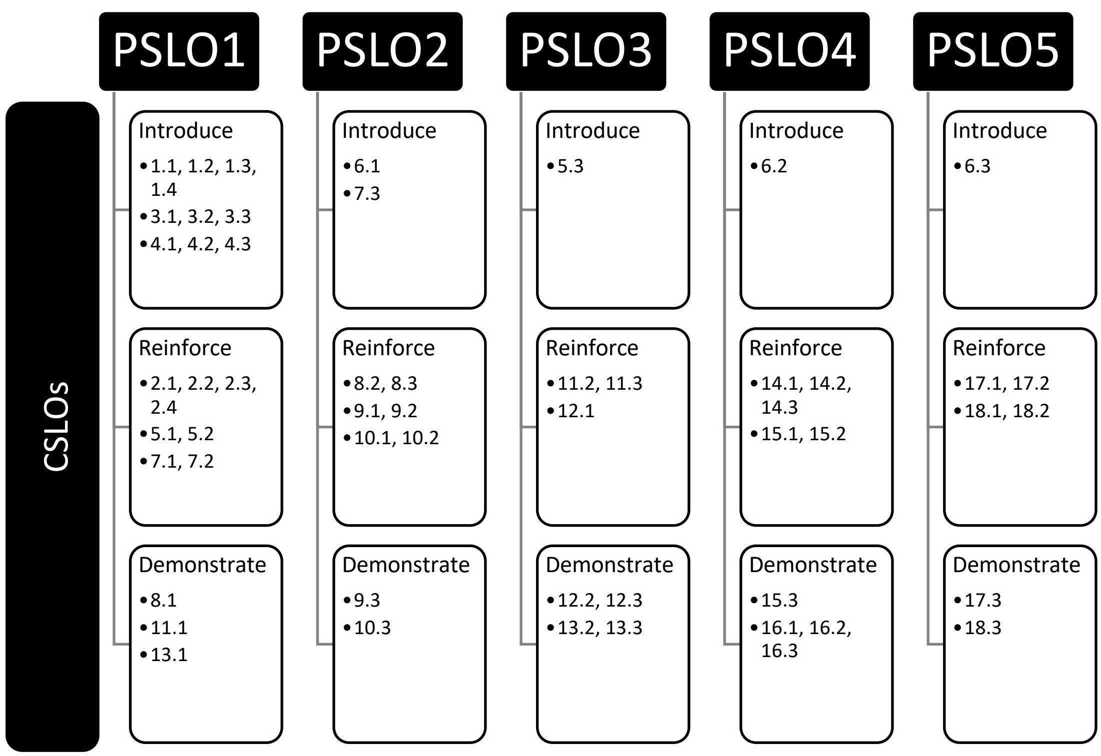

Figure 2 Curriculum Program Map

3. Developing the Skills Program Map

Once the curriculum program map was completed, the skills program map was developed. Industry job analytics reports showed trends in current job postings aligned to the field of environmental science. The report provided a list of the most prevalent technical skills, common skills, and software skills in job postings for graduates of bachelor's programs in environmental science or related fields. Some skills related to entire disciplines of science, like geology. These represent what employers are listing on job postings as desired skills for candidates. Some skills shared similarities, like budgeting and auditing. Those represent the slight differences between employer wants and needs. For clarification of those differences, job postings were examined to understand the context of each of the desired skills. Once a complete inventory of desired skills was completed, industry skills were analyzed and sorted into themes. From the themes, Program Level Skills (PLSs) were created. Those skills and themes are represented in Figure 3.

Similar to CSLOs in the Curriculum Map development process, individual skills within the theme of each PLSs were aligned to individual courses as Course Level Skills (CLSs). Each CLS was aligned to a PLSs so assessment of students at the course level, for each CLSs, is used to infer proficiency in a particular PLS. Feedback related to PLSs and CLSs was solicited from and validated by programmatic faculty and the IAC.

Natural Science	Investigation, Organization, Analytical Techniques, Scientific Modeling, Research, Data Collection, Data Analysis, Chemistry, Curiosity, Critical Thinking, Geology, Problem Solving, Innovation, Biology, Planning, Decision Making, Historical Evaluation, Value Determination, Inductive Reasoning, Chemical Acidents, Lab Techniuqes
Envrionmental Sustainability	Consulting, Interdisciplinary Analysis, Population Analysis, Application of Scientific Theory, Materials Management, Pollution Prevention, Sustainability, Budgeting, Auditing, Economics
Envrionmental Health and Safety	Communication, Chemical Waste, Toxicology, Envrionmental Health, Technical Document Review, Risk Assessment, Field Research, Spatial Analysis
Envrionmental Laws	Training and Development, Metaanalysis, Contemporary Issues, Ethics, Regulatory Compliance, Policy Change Breif, Legal Analysis, Envrionmental Planning, Regulatory Analysis, Hydrology
Envrionmental Policy	Presentations, Envrionmental Planning, Project Management, Envrionmental Management, Building Relationships, Emergency Response, Public Policy Analysis

Figure 3 Industry Skills for Environmental Science

Figure 4 shows the Skills Program Map. The 5 programmatic PLSs were determined and the CLSs were aligned to each PLS. Using the example of PLS 2, course level skills aligned to PLS 2 are first taught and assessed in the sixth and seventh course (CLSs 6.1 and 7.3). Students then have opportunities to learn additional course level skills aligned to PLS 2 in courses 8, 9, and 10 (CLSs 8.2, 8.3, 9.1, 9.2, 10.1, and 10.2). The most complex course level skills related to PLS 2 are taught and assessed in courses 9 and 10 (CLSs 9.3 and 10.3). Data from assessments provide information about students' proficiency for both individual course skills and the program skill described by PLS 2.

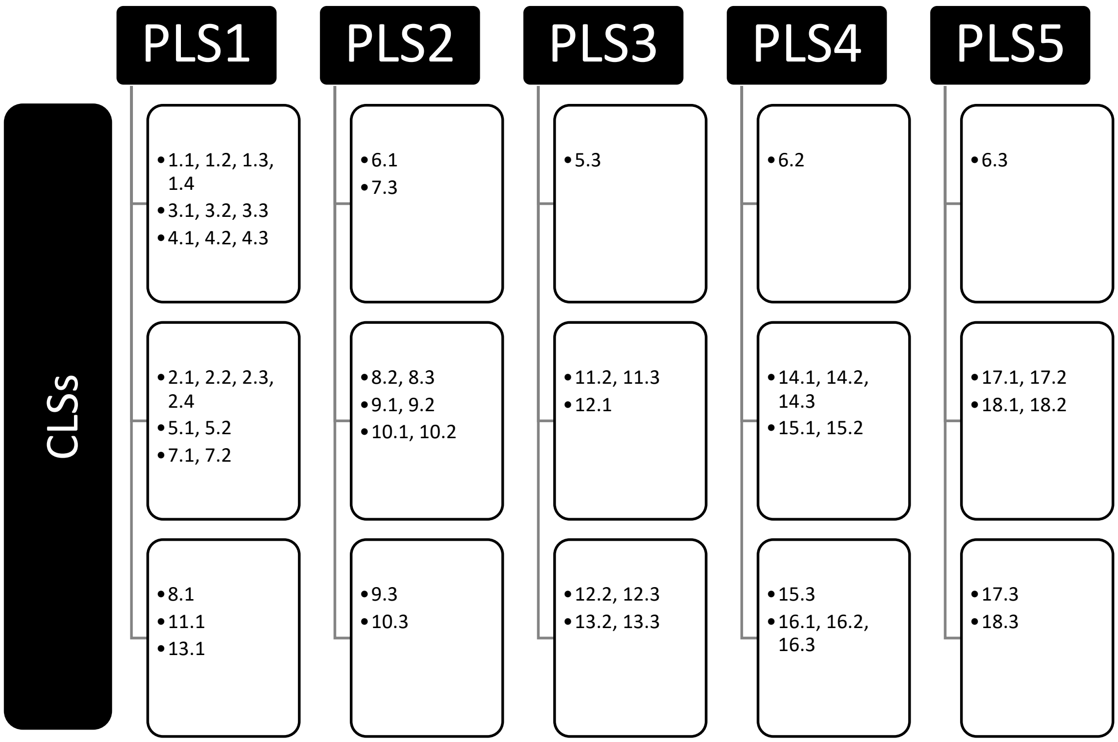

Figure 4 Skills Program Map

Once the Curriculum Program Map and Skills Program Map were complete, synthesis was required to create the Curriculum-to-Career Map for the environmental science program.

4. The Synthesis: Curriculum-to-Career Map

The Curriculum-to-Career map was developed by synthesizing the Curriculum Program Map and the Skills Program Map. Each PSLO is aligned to a PLS. Each CSLO is aligned to a CLS. As a result, the Curriculum-to-Careers Map includes both traditional knowledge and industry skill outcomes in every course and at the conclusion of the program. The synthesized map is shown in Figure 5.

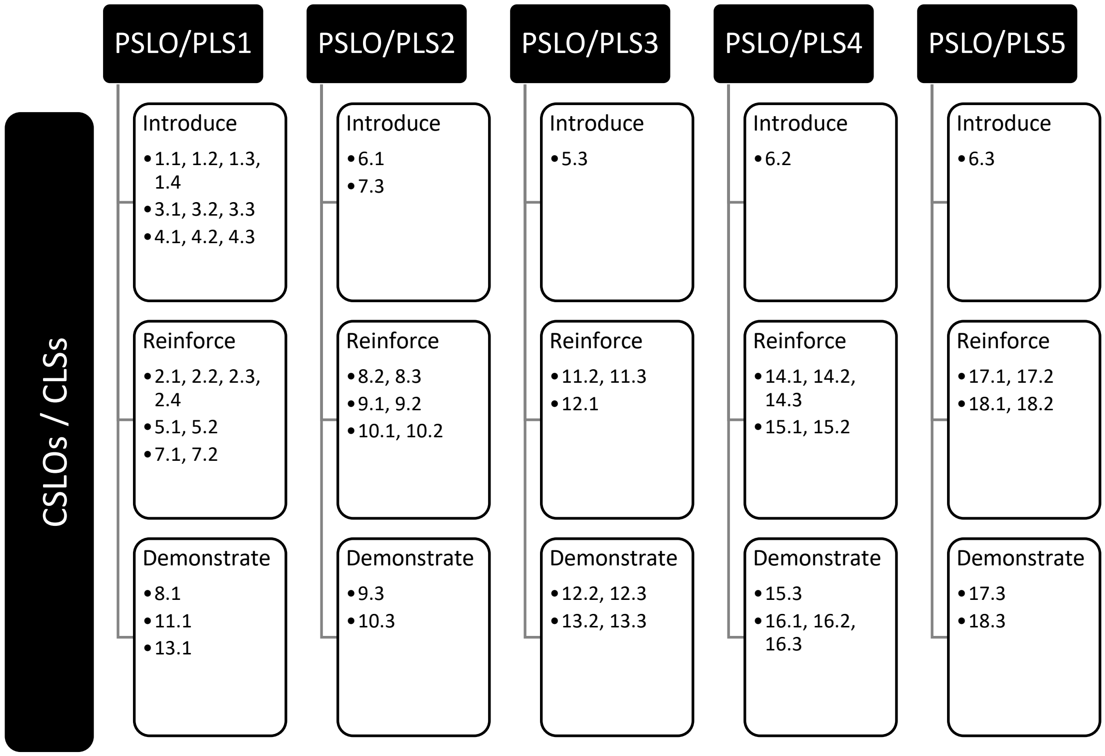

Figure 5 Curriculum-to-Careers Map

To further investigate the Curriculum-to-Career Map, we can use an example of one of the lower division core courses in the environmental science program, BIO/280 – Conservation Biology. Figure 6 shows the alignment of all components of the Curriculum–to- Careers map within the context of a single course. CSLOs and CLSs from the course are aligned to the PSLOs and PLSs of the program. Each CSLO/CLS pair is assessed through a summative assessment in the course, providing evidence of students' knowledge of the associated CSLO and CLS.

BIO/280 - Conservation Biology

PSLO1: Develop knowledge that is foundational to the physical and biological sciences PLS1: Natural Science		PSLO2: Evaluate environmental phenomena using social, environmental, and financial principles PLS2: Envrionmental Science
Reinforce. CSLO7.1: Evaluate the history of value of conservation biology. CLS7.1: Historical Evaluation	Reinforce. CSLO7.2: Assess processes for scientific research of ecosystems and related threats. CLS7.2: Value Determination	Introduce. CSLO7.3: Interpret tools and strategies available to maintain biodiversity. CLS7.3: Interdisciplinary Analysis
Skill Descriptors: • Assessment of biological ethics and values • Demonstration of intentional judgement and actionable item • Application of conservation principles to social phenomena	*Skill Descriptors:* • Evaluation of historical sources and research • Historical evaluation of protecting and restoring biodiversity	*Skill Descriptors:* • Integration of information and data to advance knowledge • Solutioning of problems through integrating interdisciplinary resources

Figure 6 Course Alignment Example to Curriculum-to-Careers Map

To support the integration of these two maps, skill descriptors were created for every CSLO/CLS pair. These skill descriptors are short statements that describe how the traditional knowledge associated with the CSLO is aligned and demonstrated by the development of the CLS. Skill descriptors are student-facing statements that support students' understanding of how to communicate their knowledge and its relevance within the context of needs in environmental science.

Feedback from industry is consistently analyzed to ensure the Curriculum-to-Careers map accurately reflects the needs of environmental science industry. Industry feedback also helps determine the ability of the environmental science program to prepare graduates to fulfill those needs.

5. Informing and Refining the Curriculum-to-Careers Map

Several points in the process generate information that inform the programmatic map. In each IAC meeting, various prototypes of courses were shared to gauge impact of the course and program development and redesign. Results from newly launched courses were explored. Course discussion and assignment details were reviewed in depth focusing on how effectively course resources align to business and industry labor force needs. This information was used to inform a development strategy for future course development. Based on IAC members' perspectives of workforce gaps in necessary skills, subject matter experts and instructional designers created assessments that allowed students to create artifacts focused on bridging these skills gaps. Consistent feedback cycles of quantitative and qualitative data synthesis were conducted and used to inform the alignment of course content to the curriculum-to-careers map.

Conclusions

The continuous loss of institutional industry knowledge and issues with tight labor markets require higher education institutions to implement thoughtful and targeted programmatic and curricular design. To overcome the knowledge gap in STEM fields, we pivoted from traditional knowledge in the scholarly community to practitioner knowledge in the STEM workforce integrated with instructional practices in the classroom. Through collaboration with the IAC outside of the education space, we collected stakeholder input to identify needs of the environmental science industry. Using the industry perspective and guided by our philosophical instructional framework, we deconstructed the curriculum at both the course and program levels to synthesize a programmatic map that closed the gap between academia and industry.

During IAC meetings, a prototype course was used to showcase course components and allow for input and changes. Upon gaining the industry leaders' feedback and determining these skills and deliverables were necessary for future hires, the path of instructional design and course development was set. We used an adaptive development plan with templates for course design. As industry feedback continued to inform development, templates became more complex through the course sequence, reflecting increasing academic rigor. Subsequent IAC meetings showcased the iterations of course development and final course deliverables and artifacts.

To further support students' understanding and ability to speak to relationships between traditional and industry knowledge, skill descriptors were created. These descriptors translate the value of the curriculum to both students and the industry. Career skill descriptors help build students' background knowledge in the subject matter by using the conceptual change theory to bridge to course student learning outcomes. By using our philosophical instructional framework to create learning experiences and assessments aligned to the curriculum-to-career map, students continuously build academic knowledge and connect that knowledge to professional practice (Kelly, Bruno, Edgecomb, Vahid, & Gordon, 2022).

Informed by the IAC, this design technique within course activities helps students to practice professional language using professional resources that mimic real-world deliverables. This student immersion in the language of professional skills in tandem with concept proficiency is initiated from the first course and continues through program completion. Adopting this curriculum-to-careers map has allowed us to map every course in the program and deconstruct all program student learning outcomes, course student learning outcomes, program-level industry skills, and course-level skills at increasing levels of rigor. The use of the curriculum-to-careers map to guide instructional choices further enhances students' expertise and provides the necessary foundation students need to address the loss of institutional knowledge in current and projected labor markets.

Businesses and industries need higher education institutions to facilitate and accelerate new hires' transition to the workforce (Beckwin, 2018; Brainard, 2022; Prior, 2022). Ideal employees have the necessary subject matter expertise and applicable career skills to contribute to the workforce upon hire. The gap between education and industry under current labor market conditions has potentially significant consequences. Gaps in STEM knowledge and skills mean decreased support for functioning industry systems. Our goal is to shift the paradigm in academia so we do our part to create a workforce capable of maintaining the systems that care for human health and safety and environmental quality.

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