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The PULSE Vision & Change Rubrics, Version 1.0: A Valid and Equitable Tool to Measure Transformation of Life Sciences Departments at All Institution Types

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ABSTRACT

The PULSE Vision & Change Rubrics, version 1.0, assess life sciences departments' progress toward implementation of the principles of the *Vision and Change* report. This paper reports on the development of the rubrics, their validation, and their reliability in measuring departmental change aligned with the *Vision and Change* recommendations. The rubrics assess 66 different criteria across five areas: Curriculum Alignment, Assessment, Faculty Practice/Faculty Support, Infrastructure, and Climate for Change. The results from this work demonstrate the rubrics can be used to evaluate departmental transformation equitably across institution types and represent baseline data about the adoption of the *Vision and Change* recommendations by life sciences programs across the United States. While all institution types have made progress, liberal arts institutions are farther along in implementing these recommendations. Generally, institutions earned the highest scores on the Curriculum Alignment rubric and the lowest scores on the Assessment rubric. The results of this study clearly indicate that the Vision & Change Rubrics, version 1.0, are valid and equitable and can track long-term progress of the transformation of life sciences departments. In addition, four of the five rubrics have broad applicability and can be used to evaluate departmental transformation by other science, technology, engineering, and mathematics disciplines.

INTRODUCTION

The disciplines of science, technology, engineering, and mathematics (STEM) play a vital role in our nation's economy, contributing to at least half of the economic growth in the United States during the past 50 years, and consistently providing a source of stable, high-earning jobs for appropriately skilled individuals (U.S. Congress Joint Economic Committee, 2012). However, there is currently concern about a shortage of qualified STEM workers. Based on data from the U.S. Bureau of

Labor Statistics, employment in STEM occupations is expected to grow to more than 9 million between 2012 and 2022, an increase of ~1 million jobs above the 2012 employment level (Vilorio, 2014). An inventory of federal expenditures on STEM education conducted by the National Science and Technology Council (2011) revealed $3.4 billion was spent, with 28% devoted to STEM workforce development and 72% expended on broader STEM education projects. Even with this substantial monetary investment, progress toward creating educational experiences that engage current students and result in an increase in the STEM talent pool and STEM graduates has fallen short.

In 2012, the President's Council of Advisors on Science and Technology (PCAST) released a report suggesting that the first 2 years of undergraduate study are the most critical for recruiting and retaining STEM majors needed to fill the STEM employment gap (PCAST, 2012). Furthermore, the report states that 60% of the students entering college intending to major in a STEM discipline do not graduate with a STEM degree. Many of the students who leave STEM majors reported that their introductory courses were uninspiring and unwelcoming, and those experiences were enough to discourage them from majoring in STEM disciplines. The PCAST report suggests that colleges and universities attempt to increase the retention of STEM majors from 40 to 50% by providing the students with an educational environment that uses evidence-based, best practices in teaching and learning, while offering the academic and social support students need to persist to earn a STEM degree.

In response to the suggestions in the PCAST report and similar reports published over the past decade (National Research Council [NRC], 2003, 2011; American Institutes for Research, 2012; National Science and Technology Council, 2013), STEM faculty, funding agencies, and stakeholders have looked more intentionally at the reasons students do not select or persist in life sciences majors. College students and faculty members have long argued that the approach to undergraduate education in the life sciences should be modernized to reflect what is known about how students learn. They assert that the pedagogies (Freeman *et al.*, 2014; Wieman, 2014) and high-impact practices known to enhance student learning (Kuh, 2008) should be incorporated into life sciences programs nationwide. Twenty-first-century science demands that students develop modern scientific and technical skills, as well as the capacity to work beyond traditional academic boundaries. Undergraduate students, regardless of their majors, deserve and need a transformed life sciences curriculum that teaches them foundational biological concepts and allows them to become adept in scientific competencies. Informed decision making, whether around managing one's health, understanding how individual actions influence the environment, or understanding political policy discussions on scientific issues (e.g., stem cell research, climate change) requires an appreciation of key biological concepts and the nature and process of science.

As a result of a nationwide conversation about the future of life sciences education, *Vision and Change in Undergraduate Biology Education: A Call to Action* was published by the American Association for Advancement in Science (AAAS) in 2011. It included a set of recommendations for transforming life sciences education. One of the most significant recommendations

of this report is the recognition that a 21st-century undergraduate education requires systemic changes to how biology is taught, how curricular decisions are made, and how academic departments support faculty in developing and implementing modern student-learning methods. Many dedicated faculty members are changing their individual courses; however, for systemic change to be effective and sustainable, it must begin at the departmental level across the range of postsecondary educational institution types.

To explore how this systemic change can be realized across the country, the National Science Foundation (NSF), the National Institute of General Medical Science of the National Institutes of Health, and the Howard Hughes Medical Institute collaborated to form the Partnership for Undergraduate Life Sciences Education (PULSE) in 2012 (Dolan, 2012). PULSE began with the selection of 40 Vision and Change (V&C) Leadership Fellows; all were current or former life sciences department chairpersons or deans from a variety of institution types, including community colleges, liberal arts colleges, regional comprehensive universities, and research universities. Initially, the V&C Leadership Fellows were charged with developing strategies to enact the recommendations of the *Vision and Change* report over a 1-year period. These strategies were intended to promote changes in the way life sciences departments institutionalize best practices in evidence-based teaching and learning, develop curricula and infrastructure, create effective strategies for motivating systemic educational change, and assess their progress with an eye toward continuous improvement. During the first year of work, the V&C Leadership Fellows developed key projects and strategies to facilitate this national effort for systemic change (www.pulsecommunity.org; Woodin *et al.*, 2012). The V&C Fellows membership has been expanded so that the concerted effort to promote and adopt the recommendations in the *Vision and Change* report can continue nationally.

A PULSE pilot recognition program was one strategy developed by a subset of the V&C Leadership Fellows. The PULSE pilot recognition program was designed to provide undergraduate life sciences departments the opportunity for guided self-reflection and peer-review feedback about their programs' progress in implementing the *Vision and Change* recommendations. Based on existing models, a set of rubrics was developed that would serve life sciences departments in this self-reflection process and measure the extent of adoption of the principles of *Vision and Change*. In 2013, the PULSE Vision & Change Rubrics, version 1.0 (V&C Rubrics), were released (Aguirre *et al.*, 2013) and made available to the life sciences community on the PULSE community website (Supplemental Material).

This paper reports on the V&C Rubrics development process, their validation, and their reliability in measuring departmental change aligned with the *Vision and Change* recommendations at different institution types. In addition, we present an analysis of the findings based on the rubric data that were collected. We address three questions: 1) Are the V&C Rubrics an appropriate measurement tool across all institution types? 2) Can the rubrics be used to evaluate the adoption of the principles of *Vision and Change* by life sciences programs across all institutional types in the United States? 3) Is it possible to measure the implementation of *Vision and Change* nationwide?

METHODS AND RESULTS

Creation of the V&C Rubrics

The development of the rubrics for a recognition program began with extensive research on existing certification/accreditation models starting with the Accreditation Board of Engineering and Technology, which accredits college and university engineering programs (www.abet.org/accreditation) through a voluntary review process. Additionally, other models that were simultaneously under development were uncovered. For example, the American Society of Biochemistry and Molecular Biology had been working for several years on an accreditation program for biochemistry and molecular biology departments based on the principles of *Vision and Change* (www.asbmb.org/accreditation). The Association of American Colleges and Universities (2010) released a set of specific guidelines to its member institutions describing how STEM departments can move toward offering more student-centered environments that include active-learning experiences (www.aacu.org/value/rubrics). And the Royal Society of Biology in the United Kingdom recently instituted an accreditation program (www.rsb.org.uk/education/accreditation) that incorporates principles similar to those outlined in the *Vision and Change* report.

The PULSE recognition team created draft versions of the Vision & Change Rubrics in January 2013. Feedback and comments with regard to rubric content and wording were collected from all PULSE V&C Leadership Fellows and life sciences faculty via the PULSE community website. In spring 2013, the face validity of the draft rubrics was tested by presenting them at professional meetings such as the National Meeting of the Society for the Advancement of Biology Education Research (SABER) and the American Society for Microbiology's Conference for Undergraduate Educators (ASMCUE). For instance, at ASMCUE, ~300 faculty members were divided into groups based on institution type, and three of the five rubrics were distributed. Attendees were asked to comment whether the rubrics would be useful and indicated modifications that were needed. Feedback was collected, revisions were made, and the PULSE V&C Rubrics were released to the life sciences community via the PULSE community website (Aguirre *et al.*, 2013). These rubrics assess 66 different criteria across five broad rubric areas: Curriculum Alignment (11 criteria), Assessment (12 criteria), Faculty Practice/Faculty Support (21 criteria), Infrastructure (10 criteria), and Climate for Change (12 criteria). A sample of the rubric structure can be found in Table 1. For each of the 66 criteria, life sciences departments select their level of progress in implementing the recommendations in *Vision and Change* from a range of 0–4 (with 4 being equivalent to exemplar progress toward implementing the recommendations and 0 being equivalent to baseline progress toward implementing the recommendations). The rubrics are accompanied by an instruction manual designed to provide guidance on rubric completion (see the Supplemental Material).

Pilot Recognition Process

In addition to the development of the V&C Rubrics and the collection of rubric data, an NSF-funded pilot recognition program was conducted to motivate life sciences departments to adopt the recommendations of the *Vision and Change* report. More than 70 schools applied and eight were selected. In this paper, the following terminology is used: doctorate-granting universities = R1, comprehensive universities and colleges = RC, liberal arts colleges = LA, and 2-year colleges = CC. These terms were selected because they have been commonly used when describing institutions of higher learning. Two were chosen from each of the four institution types based on initial evidence of transformed and innovative educational practices (Pape-Lindstrom *et al.*, 2015). The eight selected pilot institutions were asked to submit written justifications for their rubric scores and other supplemental documentation, including course syllabi, sample exams, and faculty CVs. Each school received a site visit by two recognition-team members. During the 2-day site visits, the recognition-team members met with administrators, faculty, and students; observed classes; and toured the institutions' facilities. These site visits were conducted to corroborate the information that the pilot schools submitted. The self-reported rubric scores submitted by the departments were typically in agreement with the team's evaluation of the progress made toward implementation of the principles of *Vision and Change*.

Based on evaluation of all documentation and additional information gathered at the site visits, each department was

TABLE 1. Sample structure of the V&C Rubrics

Rubric	Sections	Criteria
Curriculum alignment	A. Core Concepts	1. Evolution core concept integrated into curriculum
		2. Structure and function core concept integrated into curriculum
		3. Information flow, exchange, and storage core concept integrated into curriculum
		4. Pathways and transformations of energy and matter core concept integrated into curriculum
		5. Systems core concept integrated into curriculum
	B. Integration of Core Competencies	1. Integration of the process of science into the curriculum
		2. Integration of quantitative reasoning into the curriculum
		3. Integration of modeling and simulation into the curriculum
		4. Integration of interdisciplinary nature of science into the curriculum
		5. Communication and collaboration through a variety of formal and informal written, visual, and oral methods integrated into curriculum
		6. An understanding of the relationship between science and society is embedded in curriculum

assigned a PULSE Progression Level. PULSE Progression is modeled after the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) certification, in which buildings evaluated for specific design features are recognized with LEED Silver, Gold, or Platinum certification. Each level of achievement is associated with a specific point threshold. PULSE Progression Levels provide independent verification of a life sciences department's transformative features (Pape-Lindstrom *et al.*, 2015) and are designed to reflect the progress the department has achieved in implementing the recommendations of *Vision and Change*. Every level of PULSE Progression indicates a dedicated and concerted effort by a department to remodel its approach to life sciences education so that undergraduate teaching and learning in the life sciences are improved.

Rubric Data Collection

A Qualtrics rubric data-collection portal was created to gather institutional rubric data, and a request was sent to all PULSE community members to submit their departmental rubric data. Some institutions completed all five rubrics and submitted full data sets (n = 26). Eight of the 26 institutions that submitted full data sets were the participants in the PULSE pilot recognition program. Other institutions submitted partial data sets. For data to be included in the analysis reported here, an institution must have completed at least one full rubric. This collection method resulted in variation in the number of reports submitted for each rubric. For example, 57 data sets were analyzed for the Curriculum Alignment rubric and 35 for the Assessment rubric (Table 2).

Weighting Scheme

To evaluate and compare rubric data from different institution types, the recognition team created a weighting scheme, emphasizing criteria critical for implementation of *Vision and Change* (Table 3). Generally, the weighting scheme was informed by the team's extensive and collective experiences teaching at different institution types, the research conducted on accreditation models (Aguirre *et al.*, 2013), feedback from face validity, observations from the pilot-school site visits, and the team's vision of a fully transformed curriculum. The vision was heavily influenced by discussions with the complete PULSE Fellows membership, and with faculty from around the country at conferences and workshops. A fully transformed curriculum would include features that are highly likely to enhance the student experience and transform student learning. Aspects of the rubrics that are typically associated with practices that enhance the student experience were given higher weights, such as elements of the Assessment rubric (Momsen *et al.*, 2013; Brame and Biel, 2015; Couch *et al.*, 2015) and the Faculty Practice/Faculty Support rubric (D'Avanzo, 2013; Smith *et al.*, 2013; Wieman and Gilbert, 2014; Eddy *et al.*, 2015). Other components of the rubrics, such as elements of the Infrastructure rubric, although important, are not as critical to fully drive the enhancement of student experiences. These rubrics were therefore given lower weights.

There is a abundant literature supporting the notion that providing students with opportunities to engage in the process and practice of science enhances their learning experiences (Russell *et al.*, 2007; Freeman *et al.*, 2014; Wieman, 2014; Connell *et al.*, 2016). It is not only essential to provide engaging

TABLE 2. Entire rubric data set organized by institution type and number of reports for each rubric with unweighted and weighted mean scores and SEMs by institution type reported for each rubric

Rubric	Number of programs/departments reporting these data	Sample size	Unweighted mean (SEM)	Weighted mean (SEM)
Curriculum Alignment	57	R1: *n* = 13	2.78 (0.15)	2.67 (0.17)
		RC: *n* = 16	2.77 (0.17)	2.72 (0.17)
		LA: *n* = 11	3.02 (0.17)	2.97 (0.18)
		CC: *n* = 17	2.62 (0.12)	2.52 (0.13)
Assessment				
	35	R1: *n* = 9	1.34 (0.17)	1.35 (0.19)
		RC: *n* = 10	1.21 (0.14)	1.16 (0.16)
		LA: *n* = 8	1.67 (0.17)	1.68 (0.18)
		CC: *n* = 8	1.52 (0.26)	1.54 (0.30)
Faculty Practice/Faculty Support	49	R1: *n* = 11	2.10 (0.15)	2.07 (0.16)
		RC: *n* = 14	2.10 (0.12)	2.09 (0.12)
		LA: *n* = 12	2.42 (0.16)	2.51 (0.16)
		CC: *n* = 12	1.77 (0.11)	1.72 (0.11)
Infrastructure	28	R1: *n* = 6	2.47 (0.48)	2.43 (0.49)
		RC: *n* = 8	2.33 (0.22)	2.33 (0.23)
		LA: *n* = 7	2.57 (0.21)	2.63 (0.23)
		CC: *n* = 7	2.43 (0.30)	2.44 (0.27)
Climate for Change	32	R1: *n* = 7	1.75 (0.29)	1.75 (0.29)
		RC: *n* =11	1.59 (0.17)	1.59 (0.17)
		LA: *n* = 7	1.87 (0.29)	1.87 (0.29)
		CC: *n* = 7	1.76 (0.29)	1.76 (0.29)

TABLE 3. Rubric weighting scheme

Rubric category/section	Weighting factor	Number of criteria	Possible points
Curriculum Alignment		11	68 (11%)
A. Core Concepts	×1	5	20
B. Integration of Core Competencies	×2	6	48
Assessment		12	136 (23%)
A. Course Level Assessment	×2	7	56
B. Program Level Assessment	×4	5	80
Faculty Practice/Faculty Support		21	296 (50%)
A. Student Higher Level Learning	×6	5	120
B. Learning Activities beyond the Classroom	×4	6	96
C. Faculty Development	×2	10	80
Infrastructure		10	48 (8%)
A. Physical Infrastructure	×1	5	20
B. Learning Spaces	×2	2	16
C. Resources and Support	×1	3	12
Climate for Change (all sections)	×1	12	48 (8%)
Total		66	596 (100%)

opportunities for students, but also important to assess whether or not those opportunities are indeed enhancing student learning (Momsen *et al.*, 2013; Freeman *et al.*, 2014; Wieman, 2014; Brame and Biel, 2015; Couch *et al.*, 2015). Our weighting scheme was designed to acknowledge departments that embrace these practices and to reward more fully transformed departments with higher overall scores. Because there are often roadblocks to the implementation and measurement of these practices, the higher weights on these elements may also encourage departments to fully implement these recommendations.

Another driver for the adoption of the weighting scheme is the unequal distribution of criteria in each rubric section. In the absence of rubric data weighting, institutions that have made gains in enacting practices to enhance their students' experiences may earn lower, overall rubric scores. This may result from lower scores on the other sections of the rubrics that highlight aspects not as essential to departmental transformation toward enhancing the student experience. The site visits enabled the recognition team to align the observations they made at the institutions they visited with the unweighted and weighted rubric scores to confirm the weighting scheme model.

Examination of the Rubrics for Reliability

Statistical analyses conducted for this study were performed using Statistical Analysis System (SAS, version 9.3, for Windows, 2002–2010) and R; significance was determined at 0.05. Each rubric was initially divided into sections that, a priori, were designed to target a specific component of the rubric. Using all available data for each rubric, the internal consistency or reliability of the rubric sections was tested by computing Cronbach's α for each (Cronbach, 1951). Generally, $\alpha \geq 0.7$ is considered acceptable reliability. All sections of the Curriculum, Assessment, and Faculty Practice/Faculty Support rubrics exhibited adequate reliability. However, not all original sections of the Infrastructure and Climate for Change rubrics met this condition (Table 4).

An exploratory factor analysis (EFA; Hotelling, 1933, Fabrigar *et al.*, 1999; Suhr, 2005) was conducted to determine the most

coherent structure for each section of the Infrastructure and Climate for Change rubrics. EFA examines the underlying correlation structure of a set of items (Browne, 2001; Brown, 2009) and identifies coherent groupings within the larger set of items. Using all data for each rubric, all rubric items were included in a factor analysis, using principal components extraction with a varimax rotation (Kaiser, 1958). A factor analysis generates a number of factors equal to the number of items included in the analysis, but not all factors are retained. Each factor has an eigenvalue (indicating the proportion of variance in the data the factor accounts for), and each item has a loading for each factor, indicating how strongly the item associates with the given factor. For each analysis, the number of factors to retain based on the Kaiser criterion (all factors with eigenvalues <1 are dropped) was applied, followed by the scree test, in which all remaining eigenvalues were plotted from left to right in descending order. Factors were removed if they occurred at or to the right of the location of the plot in which the eigenvalues "leveled off." Once the retained factors were determined, each item was placed into the retained factor on which it loaded most highly.

Based on the EFA, new structures were generated for the Infrastructure and Climate for Change rubrics and Cronbach's α values were then recalculated. Table 4 shows the original rubric structure, section labels, and Cronbach's α coefficients and the revised structure, labels, and coefficients. The reclustering resulted in adequate reliability for sections, with Cronbach's $\alpha \geq 0.7$. The new groupings were also examined for conceptual coherence, to identify a conceptual underpinning and to create meaningful labels for all new sections. The reliability analyses and the EFA resulted in major revisions to the Infrastructure and Climate for Change rubrics. As a result of these revisions, all rubrics are now reliable measures of progress on the implementation of the *Vision and Change* recommendations.

Analysis of Full Rubrics Data Sets

The rubrics were developed with the hypothesis that they could be used to evaluate departmental transformation equitably across institution types. To address this hypothesis, the data

TABLE 4. Original and reclustered Infrastructure and Climate for Change rubrics based upon EFA analyses

Rubric (original rubric Cronbach's α)	Reclustered rubric with improved Cronbach's α[a]
Curriculum	
A. Core Concepts (α = 0.79)	
B. Integration of Core Competencies (α = 0.78)	
Assessment	
A. Course Level Assessment (α = 0.70)	
B. Program Level Assessment (α = 0.74)	
Faculty Practice/Faculty Support	
A. Student Higher Level Learning (α = 0.79)	
B. Learning beyond the Classroom (α = 0.80)	
C. Faculty Development (α = 0.80)	
Infrastructure	
A. Physical Infrastructure (α = 0.84)	A. Learning Spaces (α = 0.87)
Classrooms and teaching laboratories can accommodate special needs	Classrooms and teaching laboratories can accommodate special needs
Teaching spaces to encourage student interaction	Teaching spaces to encourage student interaction
Classroom IT infrastructure	Classroom IT infrastructure
Intelligently designed laboratory	*Informal gathering spaces that encourage collaboration*
Equipment/supplies in teaching laboratories	*Learning center for students*
B. Learning Spaces (α = 0.64)	B. Laboratory Spaces (α = 0.76)
Informal gathering spaces that encourage collaboration	*Intelligently designed laboratory spaces*
Learning center for students	*Equipment/supplies in teaching laboratories*
C. Resources and Support (α = 0.71)	C. Resources and Support (α = 0.79)
IT support for innovative teaching	IT support for innovative teaching
Staff support for teaching	Staff support for teaching
Institutional support for electronic resources	Institutional support for electronic resources
Climate for Change	
A. Administrative And Institutional Vision (α = 0.72)	A. Institutional Awareness and Communication of Vision (α = 0.89)
Vision is clear and specific	Commitment to vision is demonstrated through administrative action
Vision aligns with V&C priorities	*There is awareness and buy-in of national initiatives in higher education*
Commitment to vision is demonstrated through administrative action	*There is a collaborative communication process in place, including disseminating new ideas*
	There is faculty support for the administrative vision within the department
B. Administrative and Institutional Attitude (α = 0.59)	B. Strategies for Promoting Systemic Change in Teaching Culture (α = 0.78)
Administration is supportive of the need for change	Administration is supportive of the need for change
There is awareness and buy-in of national initiatives in higher education	*Vision aligns with V&C priorities*
Institutional evaluation and assessment reflects the importance of teaching	*Strategies are in place to recruit and retain diverse teaching faculty*
	Resources exist for faculty to improve their teaching methods
C. Administrative and Institutional Action (α = 0.71)	C. Concrete Implementations Promoting Change in Teaching Culture (α = 0.71)
Strategies are in place to recruit and retain diverse teaching faculty	Faculty incentives exist for transformative approaches in teaching
Faculty incentives exist for transformative approaches in teaching	*Fund-raising and development efforts support departmental transformation in alignment with Vision & Change*
Resources exist for faculty to improve their teaching methods	*Institutional evaluation and assessment reflects the importance of teaching*
Fund-raising and development efforts support departmental transformation in alignment with V&C	*Vision is clear and specific*
D. Departmental Support (α = 0.88)	
There is a collaborative communication process in place, including disseminating new ideas	
There is faculty support for the administrative vision within the department	

[a]Reclustered criteria are italicized.

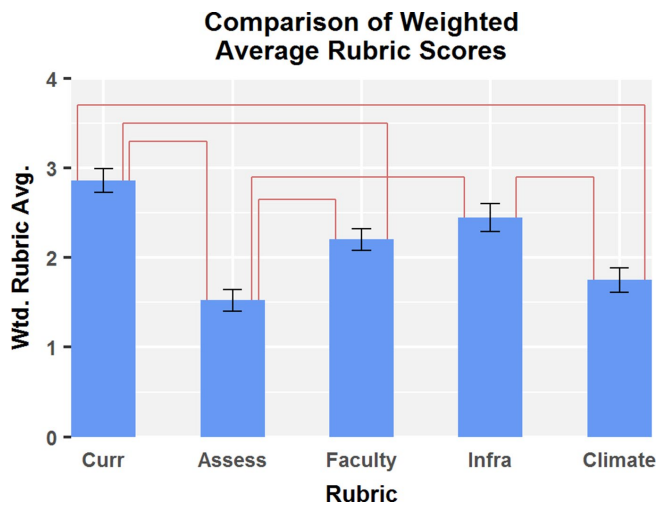## Comparison of Weighted Average Rubric Scores

FIGURE 1. Weighted average rubric scores for 26 institutions with full data sets. Values represent scores, not ranks, with a possible range of 0–4. Error bars represent the SEM. Connecting lines represent statistically significant pairwise differences ($p < 0.05$), based on post hoc analysis (Tukey-Kramer least squared [LS] means). The rubric criteria can be found in the Supplemental Material. Curr = Curriculum, Assess = Assessment, Faculty = Faculty Practice/Faculty Support, Infra = Infrastructure, Climate = Climate for Change.

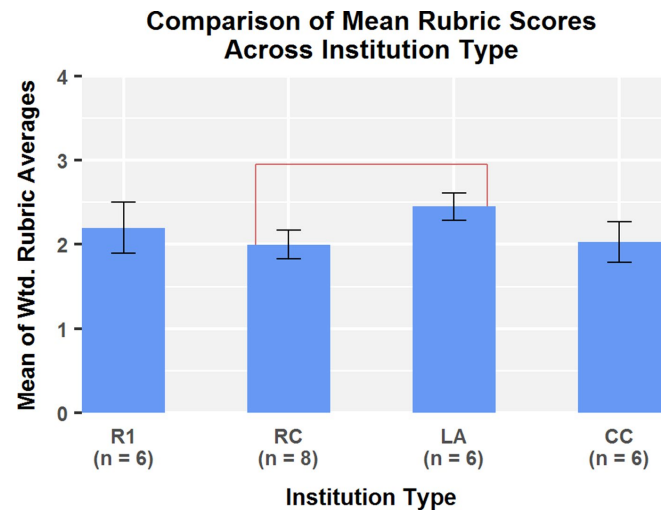## Comparison of Mean Rubric Scores Across Institution Type

FIGURE 2. Weighted average scores, collapsed across the five rubrics and grouped by institution type, for the 26 institutions with full data sets. Values represent the scores, not ranks, with a possible range of 0–4. Error bars represent the SEM. Connecting lines represent statistically significant pairwise differences ($p < 0.05$), based on post hoc analysis (Tukey-Kramer LS means). The rubric criteria can be found in the Supplemental Material.

from the 26 institutions that completed all five of the rubrics were grouped by institution type: R1, RC, LA, or CC. Of the 26 complete data sets, six were submitted by R1 institutions, eight by RCs, six by LA colleges, and six by CCs. Each institution's weighted mean score for each rubric was calculated, using the weighting scheme presented in Table 3. A two-way analysis of variance (ANOVA) of institution type versus rubric, with interaction term on ranked data (i.e., analogous to a Kruskal-Wallis test; Conover and Iman, 1981; Akritas, 1990) was performed, testing three effects: rubric main effect, institution-type main effect, and rubric × institution type interaction. Significant effects were followed with post hoc pairwise comparisons. The design was unbalanced (i.e. differing in number of replicate institutions among type), so least-squared means were used for these post hoc tests, and the Tukey-Kramer method was used to adjust for multiple comparisons.

The rubric main effect directly tested whether implementation differed across the various rubrics, and the significant main effect ($F(4110) = 15.46$, $p < 0.01$) indicates significant variation across rubrics. Notably, departments reported the highest degree of implementation on curriculum and the least implementation on assessment. Figure 1 and Table 5 display the

TABLE 5. p Values for post hoc analysis (Tukey-Kramer LS means) pairwise comparisons of weighted average rubric scores in Figure 1

	Curr	Assess	Faculty	Infra	Climate
Curr		<0.001	0.01	0.36	<0.001
Assess			<0.01	<0.001	0.75
Faculty				0.64	0.12
Infra					<0.01
Climate					

Curr = Curriculum, Assess = Assessment, Faculty = Faculty Practice/Faculty Support, Infra = Infrastructure, Climate = Climate for Change.

pattern of means and an indication of which rubric scores significantly differed from one another.

The rubrics were developed with the intent to evaluate departmental transformation equitably across all institution types. Figure 2 shows the mean scores, collapsed across rubrics and grouped by institution type. It is intended that the rubrics will be used to evaluate progress over time. The data presented here represent a baseline measurement. The question of whether the rubrics equitably measure progress across all institution types was addressed by the institution-type main effect and the interaction term of the aforementioned ANOVA. The institution-type main effect was significant ($F(3, 110) = 3.04$, $p < 0.04$), indicating significant differences across institution types, collapsed across all rubrics. Post hoc tests revealed that the LA institutions had significantly higher means than the RCs, and no other differences were significant (Figure 2). The interaction term was not significant ($F(12, 110) = 0.71$, $p > 0.7$), indicating that the relative standing of institution types does not significantly differ across the rubrics. Although LA and RC institutions significantly differ from each other, there is considerable overlap in the score distributions of these groups. The data show that even the institution type with the lowest mean score has representative institutions that score nearly as high as any other institution in the data set.

Overall, the analysis of full data sets reveals significant differences in progress across rubrics, with the most progress reported in the area of curriculum alignment and the least on assessment. However, examining the distribution of scores suggests no inherent bias exists that would prevent any particular institution from achieving high scores.

Analysis of Individual Rubrics

Many institutions did not complete all five rubrics (Table 2). Therefore, analyzing the data from each rubric separately

TABLE 6. ANOVA tables for analyses of rubric scores and ranked rubric scores

Measure[a]	SS_{Effect}	SS_{Error}	df_{Effect}	df_{Error}	MS_{Effect}	MS_{Error}	F	p Value
One-way (institution type) ANOVAs on weighted averages								
Curr	1.36	19.59	3	53	0.45	0.37	1.23	0.31
Assess	1.33	11.41	3	31	0.44	0.37	1.20	0.33
Faculty*	3.75	10.57	3	45	1.25	0.23	5.32	<0.001
Infra	0.34	15.37	3	24	0.11	0.64	0.18	0.91
Climate	0.36	13.65	3	28	0.12	0.49	0.24	0.86
Faculty-A*	4.86	18.08	3	45	1.62	0.40	4.03	0.01
Faculty-B*	8.81	17.94	3	45	2.94	0.40	7.37	<0.001
Faculty-C	0.62	17.28	3	45	0.21	0.38	0.54	0.66
One-way (institution type) ANOVAs on ranked weighted averages								
Curr	938.97	14439.03	3	53	312.99	272.43	1.15	0.34
Assess	374.54	3184.46	3	31	124.85	102.72	1.22	0.32
Faculty*	2338.99	7454.01	3	45	779.66	165.64	4.71	0.01
Infra	61.36	1755.14	3	24	20.45	73.13	0.28	0.84
Climate	60.59	2659.41	3	28	20.20	94.98	0.21	0.89
Faculty-A*	1946.22	7756.28	3	45	648.74	172.36	3.76	0.02
Faculty-B*	3816.51	5902.00	3	45	1272.17	131.16	9.70	<0.001
Faculty-C	320.64	9430.86	3	45	106.88	209.57	0.51	0.68

[a]An asterisk indicates that the main effect of institution type was significant for this measure ($p < 0.05$). The four categories of institution type are R1, RC, LA, and CC. SS = sum of squares, MS = mean sum of squares; A, B, and C refer to sections of the Faculty Practice/Faculty Support rubric; see Table 3.

allowed larger sample sizes for statistical analyses. In these analyses, a series of one-way ANOVAs was conducted with institution type as the independent variable and a given weighted rubric score as the dependent variable. These analyses were conducted with ranked data and weighted scores. Post hoc tests used least-squared means and the Tukey-Kramer method to correct for multiple comparisons. Results of ANOVAs on ranks (Kruskal-Wallis) and ANOVAs on scores yielded similar results (Table 6), with the only significant effect of institution type emerging on the Faculty Practice/Faculty Support rubric. Therefore, graphs of the data present ANOVAs on the scores themselves, not the ranked scores.

The data in Figure 3A and Table 6 indicate that the Faculty Practice/Faculty Support rubric shows significant differences by institution type. Figure 2 displays the mean weighted scores, grouped by institution type, and indicates statistically significantly differences based on the post hoc comparisons. Overall, LA institutions scored the highest on Faculty Practice/Faculty Support. As shown in Figure 3A, the only significant pairwise comparison was between LA colleges and CCs. Further analysis examined the scores on the three sections of this rubric (A = student higher-level learning, B = learning activities beyond the classroom, and C = faculty development) to identify the sources of difference in scores for this rubric. A significant main effect of institution type was found for both sections A and B. Figure 3, B and C, shows the overall pattern of means for these sections and indicates which groups are significantly different from one another based on post hoc comparisons.

Analysis of Weighing Scheme Impact

Unweighted and weighted mean scores are shown in Table 2. For each rubric, a two-way ANOVA of institution type versus weighting scheme was conducted, with an interaction term. The interaction term, weighting versus institution type, was found to be significant for the Faculty Practice/Faculty Sup-

port rubric ($F(3, 45) = 3.12$, $p = < 0.05$). For this rubric, the weighting scheme slightly increased the scores of the LA institutions and slightly decreased scores of the CC, RC, and R1 institutions (Table 2). This is likely due to LA schools reporting higher scores on sections of this rubric with higher weighting, student higher-level learning, and learning activities beyond the classroom (sections A and B, Table 3), while the other institution types score relatively well on Faculty Development (section C, Table 3). Indeed, we can think of LA institutions as models for the student experience and so it is not surprising these sections of the rubric showed a benefit to LA institutions.

Significance of Rubric Sections to Scores

An additional analysis was conducted to determine which sections were most important in terms of their association with overall rubric performance. First, principal components analysis (PCA) on the rubric section scores using the reclustered sections in the case of Infrastructure and Climate for Change was conducted. In PCA, linear combinations of the input variables, called principal components (PCs), are extracted from the data, such that PC 1 is the linear combination that extracts the maximum amount of variance from the data, and each successive PC extracts decreasing amounts of variance. In this way, much of the variance in the data can be retained with relatively few PCs. PC 1 can be considered a one-dimensional representation that best captures the overall variation in the 13-dimensional variable space. The results (Figure 4) indicate that an institution's performance on curriculum B, which measures progress on the six core competencies, indicates stronger performance on the rubrics overall and is most important in score discrimination between institutions. The A section of the Faculty Practice/Faculty Support rubric, which measures elements of student higher-level learning, is the second most important section in discriminating between schools.

Faculty Practice/Support Scores
Across Institution Type

A. Faculty

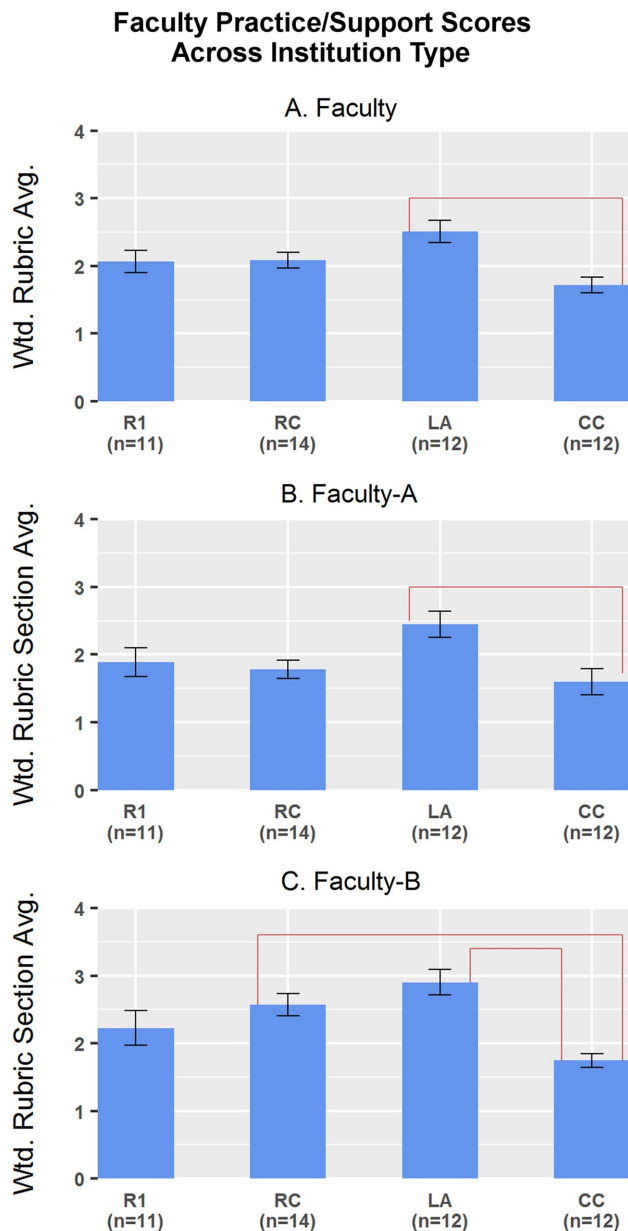### B. Faculty-A

C. Faculty-B

FIGURE 3. Weighted average scores, grouped by institution, for the Faculty Practice/Faculty Support rubric. (A) Overall rubric score, which is a weighted average of sections A, B, and C. (B) Score of section A, which contains five criteria that address inquiry, metacognition, and higher-order cognitive processes. (C) Score of section B, which contains six criteria that address learning activities beyond the classroom. Values represent the scores, not ranks, with a possible range of 0−4. Error bars represent the SEM. Connecting lines represent statistically significant pairwise differences ($p < 0.05$), based on post hoc analysis (Tukey-Kramer LS means). In addition to those marked as significant, the difference between LA and RC was marginally significant for section A ($p = 0.0504$), and the difference between R1 and LA was marginally significant for section B ($p = 0.06$). The specific rubric criteria can be found in the Supplemental Material.

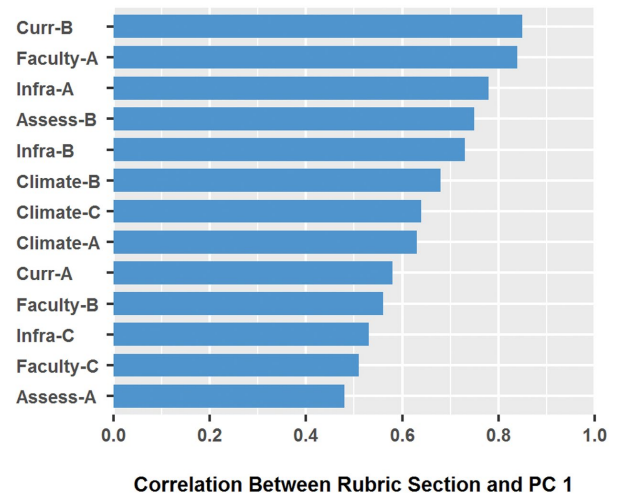**Correlation Between Rubric Section and PC 1**

FIGURE 4. PCA including all 26 institutions with full data sets. PC 1 is the first PC extracted from a PCA including the full data sets from the 26 institutions. The inputs to the PCA were the weighted averages for the 13 rubric sections (listed along the *y*-axis), and PC 1 is the best linear combination of those rubric section scores, in terms of retaining the most variance from the original input variables. The horizontal bars represent the correlation between each individual rubric section, and PC 1, among the 26 full data sets. This correlation indicates how strongly each rubric section was associated with the overall pattern of variation in the data across all rubric sections.

National Progress with Regard to the Implementation of Vision and Change

Of the 26 complete data sets, six were submitted by R1 institutions, eight by RC institutions, six by LA colleges and six by CCs. For each institution, a total weighted score was computed to provide a single overall index of the progress made in adopting the *Vision and Change* recommendations. Out of a possible 596 points, total weighted scores ranged from 167 to 441 (Figure 5). The higher the total weighted score, the more progress the institution has made toward implementing the recommendations in *Vision and Change*.

Generally, institutions had the highest scores on the Curriculum Alignment rubric and the lowest scores on the Assessment rubric (Figure 1). The rubrics were capable of discriminating between institutions based upon their rubric scores, indicating the level of incorporation of *Vision and Change* report recommendations. Examination of the data submitted revealed that all institution types have made the most progress in terms of issues related to curriculum alignment; these scores were generally the highest across all institutions. Fifty-seven institutions submitted data for the Curriculum Alignment rubric with no significant differences found by institution type for these scores. The least degree of implementation appears to be in the area of course-level and program-level assessment. There were no statistical differences in the scores submitted among the 35 reporting institutions who reported data for the Assessment rubric. These data represent baseline scores. As institutions report their rubric scores in the future, comparison with baseline data will
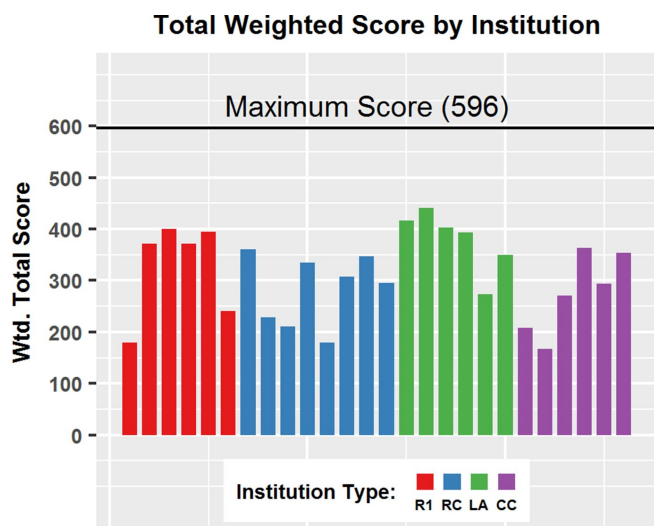
Total Weighted Score by Institution

FIGURE 5. Values represent the total weighted scores of the 26 institutions that completed all five rubrics. Each bar represents the total score from a single institution. Bars are grouped by institution type for ease of comparison. The maximum possible score is 596. See Table 3 for the weighting scheme. All of the rubric criteria can be found in the Supplemental Material.

allow the determination of the transformational progress made in life sciences departments according to the recommendations of *Vision and Change.*

DISCUSSION

Rubrics are known to provide a reliable way to conduct assessment, foster self-analysis and self-reflection (Jonasson and Svingby, 2007), and serve as accountability structures required for successful change in higher education (Kezar, 2009). In this study, weighted rubric scores were analyzed as complete data sets for 26 institutions and further analyses with larger sample sizes (Table 2) were conducted on the five individual rubrics that comprise the V&C Rubrics. Based on the statistical findings, the V&C Rubrics are a valid measurement tool to assess the state of implementation of the recommendations of *Vision and Change*, regardless of institution type. Four of the five rubrics, Curriculum Alignment, Assessment, Infrastructure, and Climate for Change, show no statistical differences by institution type (Table 6). There are statistical differences by institution type for the Faculty Practice/Faculty Support rubric (Figure 3, A–C, and Table 6) and some benefit to LA institutions via the weighting scheme. However, overall, each institution type has the potential to receive any score (Figure 5), and thus, as a whole, the V&C Rubrics do not show institutional bias.

Curriculum Alignment

The Curriculum Alignment rubric addresses the degree to which the core concepts and competencies of *Vision and Change* are integrated throughout the life sciences curriculum. For the 26 institutions that reported complete rubric data sets, the majority had the highest scores on this rubric (Figure 1 and Tables 2 and 5). In addition, higher scores were achieved on the core concepts section and lower scores were reported for the core competencies. Of all of the *Vision and Change* recommen-

dations, the core concepts are probably the least controversial, because they focus on specific biological topics that are generally agreed upon. However, many schools report lower scores for the "systems" concept. One possible explanation is that an understanding of biological systems often requires a deep understanding of biological concepts and mathematical relationships and models, as well as higher-level cognitive skills. These skills are not easily acquired by undergraduate students and require repeated practice and feedback (Ambrose *et al.*, 2010). Roadblocks to implementation of experiences to address systems biology may include a lack of faculty expertise in this area and/or a lack of emphasis on the development of higher-order cognitive abilities.

Alternatively, this may indicate a gap in curriculum development efforts. Henderson and Dancy (2011) report that most research-based instructional strategies have been developed at elite LA colleges or research universities; these curricula might not be directly transferable to other institution types. With the use of the V&C Rubrics, all institution types can evaluate their life sciences curricula in a systematic manner and identify their specific needs. In addition, curriculum review will inform all those engaged in its development as to which aspects are transferable and which require customization.

Assessment

The Assessment rubric evaluates a department's emphasis on the development and assessment of student learning outcomes at the course and program level using common course assessment tools and pre- and postcourse assessment tools. Departments across all institution types generally reported lower scores on this rubric, indicating that work on assessment needs to be a priority (Figure 1 and Tables 2 and 5). Few STEM educators at the collegiate level have undergone formal training in the areas of effective teaching pedagogies and their evaluation. To remedy this situation, many disciplinary societies and professional organizations have offered faculty development experiences (Baldwin, 2009). Wieman (2007) contends there is a knowledge base for the development of authentic assessment tools to measure student learning. However, to carry out this work would require a substantial investment of institutional resources. Also, institutional culture has provided little motivation for departments to gather and analyze assessment data and implement pedagogical changes based on their findings. It is expected that scores on this rubric will increase in the future as more institutions are asked to become more reflective about what students are learning and educators begin to use assessment data gathered via validated instruments, such as concept inventories, to strategically examine their pedagogical practice, improve the classroom experience, and increase student learning (Anderson *et al.*, 2002; D'Avanzo, 2008; Smith *et al.*, 2008; Smith and Tanner, 2010; Nadelson and Southerland, 2010; Shi *et al.*, 2010).

Faculty Practice/Faculty Support

The Faculty Practice/Faculty Support rubric evaluates the level of student-centered pedagogies, exposure to inquiry in course work, student access to authentic research experiences, and the extent and diversity of faculty development activities. Overall, LA colleges scored higher than R1 and RC institutions and CCs; the difference in scores between LA colleges and CCs was statistically significant (Figure 3A and Tables 2 and 5). When the

ANOVA was performed at the section level, LA colleges scored higher than both RC institutions and CCs on section A, "student higher-level learning" (Figure 3B). For section B, "learning activities beyond the classroom," there were additional differences between institution types. LA colleges scored statistically higher than CCs and R1 institutions, and the scores of the RC institutions were also higher than those of CCs (Figure 3C). All of these findings fit with the typical mission of the different institution types. LA colleges are noted for their high teacher-to-student ratios and their emphasis on creative and critical thinking. Additionally, they enrich students' experiences via faculty-mentored research projects and increased faculty–student interactions (Fortenbury, 2014).

Historically, providing extramural research opportunities for students has been considered outside the mission of CCs. However, as more faculty become informed that undergraduate research experiences are a documented high-impact practice (Kuh, 2008), CCs across the country are beginning to emphasize them and provide their student populations with authentic research programs (Wei and Woodin, 2011; Bangera and Brownell, 2014), such as the Community College Undergraduate Research Initiative (Berrett, 2012; Hensel and Cejda, 2014). This trend is particularly important, as CCs serve student populations more diverse than 4-year colleges (Labov, 2012). Participation in an authentic research experience has been shown to be an effective strategy to lessen the performance gap and increase the retention of students from backgrounds traditionally underrepresented in STEM (American Institutes for Research, 2012).

The main emphasis of R1 and RC institutions is research productivity. As such, support at these institutions for the practices measured by this rubric has traditionally been limited. Many of these institutions are beginning to recognize the importance of student-centered and inquiry-based learning and are now offering programs to help their faculty develop these teaching skills. Some of these institutions have realized that the transition to incorporate evidence-based teaching techniques known to foster student learning will be stimulated by hiring faculty with science education expertise (Bush et al., 2006). It has been reported that departments that have created faculty positions to implement inquiry-based, high-impact practices and evidence-based research practices in their courses have been able to enact change (Wieman et al., 2010).

Infrastructure
The Infrastructure rubric evaluates availability of flexible, reconfigurable teaching spaces, informal learning spaces, technological infrastructure, and well-designed laboratories. Although LA colleges scored highest on this rubric, the scores among the four institution types were fairly close (Table 2). Individual departments do not directly control infrastructure. The personnel, space, and equipment largely reflect the institution's monetary resources and the commitment of the institution to national education reform efforts. It should be noted that Infrastructure rubric section A, Physical Infrastructure, was the third most important factor in determining differences between institutions (Figure 4).

Climate for Change
The Climate for Change rubric gauges the specificity and clarity of institutional and administrative vision, the effectiveness of communication, and support for the development and modification of institutional policies and practice. The reported scores by all institutions are relatively low compared with scores on other rubrics (Figure 1 and Tables 2 and 5). Similar to infrastructure, individual departments do not directly control the entire institution's climate. However, this rubric provides critical insights into whether departments are capable of implementing the recommendations of Vision and Change, particularly those that require institutional resources for faculty development and incentives to improve the students' educational experiences. The culture of an institution needs to be considered for change to be effective (Henderson et al., 2011). Although individual faculty can change their teaching approaches and implement assessment procedures to improve student learning outcomes, change will not be sustainable unless an institution values these efforts and reflects them in their reward systems.

Analysis of Full Rubrics Data Sets
Although many life sciences educators are familiar with the use of rubrics as instruments for assessing student work (e.g., AAC&U Valid Assessment of Learning in Undergraduate Education [VALUE] Rubrics), there are few rubrics available that evaluate departmental activities, and even fewer that measure institutional change. Recently, there has been some movement in this arena, as the National Center for Engineering Pathways to Innovation—Epicenter—has begun to address institutional change in engineering education (Nilsen et al., 2015). Epicenter reports that the V&C Rubrics were influential in developing their tool. Similar to the V&C Rubrics, the Epicenter tool will enable the collection of an extensive data set from varied institution types that will inform large-scale improvement in undergraduate education.

The analysis of the 26 full data sets across various institution types has provided baseline knowledge and insights about the state of the adoption of the recommendations of the Vision and Change report. Some institutions have made more progress than others (Figure 5). Factors affecting the extent of progress may be the level of institutional commitment to change, the willingness of faculty to embrace new ideas about the student experience in life sciences education, and the support faculty receive to change their current practice.

Implications for STEM Transformation
Watkins and Mazur (2013) reported that the reasons students leave science majors at 4-year institutions include a lack of student–faculty interaction in the classroom and presentation of content in a manner that fails to engage the students. To retain students in STEM majors, Suchman (2014) recommends that institutions assign tenure-track faculty to teach introductory courses, as these faculty tend to be more invested in the institution. Active learning has been documented to increase student performance (Freeman et al., 2014). The V&C Rubrics have taken this into account and reflect the importance of faculty use of validated tools to record the time students spend engaged in active-learning activities (Smith et al., 2013; Wieman and Gilbert, 2014; Eddy et al., 2015). Faculty will be able to assess the quantity and quality of the active learning taking place in their classes as they use these tools. As studies on active-learning techniques continue, this evidence will assist in determining

which specific active-learning techniques produce the greatest learning gains.

Providing incentives will help motivate faculty to learn more about evidence-based teaching practices and the cognitive science that supports such practices. Faculty evaluation metrics that take into account and reward use of best practices would also stimulate change in faculty teaching practice. These structural changes would motivate faculty to develop courses with active, collaborative, and inquiry-based learning. The V&C Rubrics can be used to document changes in the teaching practices of individual faculty members over time and to help motivate departments to initiate and sustain change through benchmarking progress and encouraging department-level reflection and discussion.

Research universities have been reported as having the most difficulty in changing their educational practices (Anderson *et al.*, 2011). The typical culture of these institutions places teaching and research in direct competition, with the status and progress of faculty members almost exclusively dependent on their ability to conduct research and acquire grant funding. However, teaching and research are equally valuable pursuits, as both are capable of generating new knowledge (Boyer, 1990). Research universities excel at postbaccalaureate education, conducting scientific research, and training new scientists, and historically have placed less emphasis on the development of their faculty as educators and on their work with undergraduates. Until chairpersons, deans, and college/university presidents increase the value placed on evidence-based, student-centered pedagogies, teaching will continue to be undervalued at these institutions. Although research universities seem to be viewed as having the greatest number of obstacles to transforming teaching and learning for undergraduates, the data suggest that all institutions are facing challenges. The V&C Rubrics provide an avenue for faculty to start conversations about the status of teaching and learning in their departments, reflect on accomplishments and opportunities for improvement, and determine their departments' future directions.

The magnitude and importance of the recommendations called for in the *Vision and Change* report have caused some authors to wonder whether the life sciences and larger STEM communities are up to the task of enacting the vision (D'Avanzo, 2013; Talanquer, 2014). D'Avanzo has specifically called out the lack of "evidence-based, realistic models for actually achieving the desired 'change' broadly." The PULSE V&C Rubrics can be used as a validated framework to evaluate the implementation of *Vision and Change* recommendations.

Overall, change in higher education is challenging. Many faculty are entrenched in the tradition of supplying content in a lecture format (Brownell and Tanner, 2012). College officials in leadership positions too often consider budgetary constraints rather than the current body of knowledge about how students effectively learn science. For improvements in teaching and learning to occur, science chairpersons need to enable faculty to become knowledgeable about effective teaching practices and to provide the time required to change one's teaching approach (Association of American Universities Undergraduate STEM Initiative, 2013). In addition, advocating and maintaining these departmental transformation efforts will require the development of leaders within the faculty ranks (Elrod and Kezar, 2014).

Few models exist that could provide possible schemes to successfully promote departmental and institutional change. Frechtling *et al.* (2015) developed the Innovation through Institutional Integration program (I³), which conducted six case studies on institutions with multiple science education grants. Participating schools submitted documents for review, and the I³ team conducted site visits and interviews. The schools most successful in the implementation and sustainability of their grant-developed programs were those in which high-level administrators were deeply involved. Change in life sciences education will need the support of administrators. The V&C Rubrics can support change by providing an institution's leadership with documentation on how well a particular department has implemented the practices called for in national reports such as *Vision and Change* (AAAS, 2011) and *Engage to Excel* (PCAST, 2012). For transformation to be effective and sustained, change agents must clearly articulate their strategies, collect evidence, and report the effectiveness of these strategies. The V&C Rubrics can supply feedback and assist in the monitoring of change as new directions in a department are sought. This tool is one of the few available measures of departmental transformation.

The V&C Rubrics are widely applicable to all STEM disciplines. Only the Curriculum Alignment rubric is specific for life sciences. For other STEM disciplines, such as chemistry and physics, resources are available from the American Chemical Society and the American Physical Society, respectively, that could be used to assist departments in these STEM disciplines in developing a rubric to measure discipline-specific curricula. All STEM disciplines can use the other four rubrics as a means of departmental and institutional self-reflection and evaluation of current practices. Although institutional effectiveness has been measured (e.g., accreditation by external agencies), these high-stakes evaluations have been slow to promote change. For desired and meaningful change to occur, institutions need to determine what is essential for their transformation using a collaborative and reflective approach. For example, the use of departmental collaborative management has been linked with faculty use of more student-centered instruction (Borrego and Henderson, 2014). When a collaborative approach is used to implement system-wide change, team members are typically more invested, leading to greater chances of success in institutionalizing the structural changes that will support the transformation of STEM curricula and lead to improved student learning outcomes.

A theory of change is a predictive assumption about the relationship between the anticipated changes and the actions that may create those changes (Kezar *et al.*, 2015). Kezar (2001, 2009) has reviewed the multidisciplinary-change research literature and recognized six major theories of change (evolutionary, teleological, life cycle, political, social cognitive, and cultural). Change in higher education is a complex and multifaceted process that requires elements of multiple theories of change to enable deep and complex changes (Kezar, 2009). Additionally, change in higher education needs to be contextualized to the specific institutional setting. Specific criteria of the V&C Rubrics give concrete examples of how to implement and institutionalize change, with several detailing specific structures that will enable change. Furthermore, the development of new structures is a significant element in both the evolutionary and

the teleological (planned change) theories of change. The social cognitive theory of change includes sense-making as an essential element. Sense-making is the process by which people give meaning to experience, and one of the levers for creating new sense is data (Kezar, 2009). Faculty are able to use the V&C Rubrics to gather data regarding the current status of their departments and discuss these with their colleagues. Various criteria of the five rubrics address many elements across these six theories of change, thus enacting features of multiple theories of change simultaneously. As groups of faculty collaborate to complete the rubrics, they will come to understand more completely the context or circumstances of their own institutions, which will better inform their change efforts.

Future Work

The recognition team has recently released a revised set of rubrics, Vision & Change Rubrics, version 2.0, available at www.pulsecommunity.org/page/recognition. Based on feedback from the life sciences community and the data described herein, the rubrics were revised so the criteria were more clearly delineated. Additionally, the instruction manual was revised to provide better guidance on how to complete the rubrics. The revised Vision & Change Rubrics will be used in an ongoing effort to gather additional data about the implementation of *Vision and Change* recommendations, creating a unique longitudinal data set that will track the progress of life sciences department in adopting the *Vision and Change* report recommendations.

As previously described, the V&C Rubrics are composed of 66 criteria. When departments use these rubrics, they are able to obtain a detailed view of their implementation of the recommendations in the *Vision and Change* report in the areas of Curriculum Alignment, Assessment, Faculty Practice/Faculty Support, Infrastructure, and Climate for Change. Departments may find it difficult to begin this self-reflective process. However, the authors of this paper are confident that the process is worth conducting, as information revealed to a department can be used to strategically guide future directions of the department and the institution. The V&C Rubrics were intentionally created to be highly detailed to enable STEM departments to gather information about their current status, successes, and opportunities for improvement.

Some departments might not be ready to conduct a complete analysis based on the full rubrics. With this in mind, the PULSE recognition team has also created the Vision & Change Snapshot Rubric (Supplemental Material). This abridged version evaluates 17 criteria and is accompanied by instructions to guide its completion. These criteria reflect elements of all five rubrics and provide an indication of the status of a department in areas significant to adoption of the *Vision and Change* recommendations. The Vision & Change Snapshot Rubric has been used at conferences and regional workshops to help faculty and administrators begin a collaborative, collegial review process that effectively reveals areas of strength and those that need greater attention.

Education research is conducted by a process similar to that of disciplinary research. In recent years, life sciences have focused on the collection and analysis of large data sets. Guided by these research principles, the recognition team is working to collect rubric data from departments throughout the country,

generating a national data set. This will represent one of the first comprehensive data sets in life sciences education and will allow long-term tracking of the progress of transforming life sciences departments nationwide. To create this data set requires the engagement of the science education community at large. Institutions will need to submit their baseline rubric data and then examine their progress by completing the rubrics after departmental change strategies to improve teaching and learning have been implemented. Once analyzed, these data will indicate the degree of national implementation of *Vision and Change*, drive the future directions of STEM education research, and further facilitate the transformation currently underway in classrooms, departments, and across higher education.

REFERENCES

Aguirre KM, Balser TC, Jack T, Marley KE, Miller KG, Osgood MP, Pape-Lindstrom PA, Romano SL (2013). PULSE Vision & Change Rubrics. CBE Life Sci Educ 12, 579–581.

Akritas MG (1990). The rank transform method in some two-factor designs. J Am Statis Assoc 85, 73–78.

Ambrose S, Bridges M, DiPietro M, Lovett M, Norman M (2010). How Learning Works: Seven Research-Based Principles for Smart Teaching, San Francisco, CA: Wiley.

American Association for the Advancement of Science (2011). Vision and Change in Undergraduate Biology Education: A Call to Action. http://visionandchange.org/files/2011/03/Revised-Vision-and-Change-Final-Report.pdf (accessed 24 September 2015).

American Institutes for Research (2012). Broadening Participation in STEM: A Call to Action. www.air.org/sites/default/files/downloads/report/Broadening_Participation_in_STEM_Feb_14_2013_0.pdf (accessed 24 September 2015).

Anderson DL, Fisher KM, Norman JG (2002). Development and validation of the Conceptual Inventory of Natural Selection. J Res Sci Teach 39, 952–978.

Anderson WA, Banerjee U, Drennan CL, Elgin SCR, Epstein IR, Handelsman J, Hatfull GF, Losick R, O'Dowd DKO, Oivera BM, et al. (2011). Changing the culture of science education at research universities. Science 331, 152–153.

Association of American Colleges and Universities (2010). Valid Assessment of Learning in Undergraduate Education (VALUE) Rubrics. www.aacu.org/value-rubrics (accessed 2 November 2016).

Association of American Universities Undergraduate STEM Initiative (2013). Framework for Systemic Change in Undergraduate STEM Teaching and Learning. www.aau.edu/workarea/downloadasset.aspx?id=14357 (accessed 24 September 2015).

Baldwin RG (2009). The climate for undergraduate teaching and learning in STEM fields. New Dir Teach Learn 117, 9–17.

Bangera G, Brownell SE (2014). Course-based undergraduate research experiences can make scientific research more inclusive. CBE Life Sci Educ 13, 602–606.

Berrett D (2012). With NSF support, research moves into science labs of 2-year colleges. Chronicle of Higher Education. http://chronicle.com/article/With-NSF-Support-Research/130339 (accessed 10 December 2015).

Borrego M, Henderson C (2014). Increasing the use of evidence-based teaching in STEM higher education: a comparison of eight change strategies. J Eng Educ 103, 220–252.

Boyer E (1990). Scholarship Reconsidered: Priorities of the Professoriate, San Francisco, CA: Jossey-Bass.

Brame CJ, Biel R (2015). Test-enhanced learning: the potential for testing to promote greater learning in undergraduate science courses. CBE Life Sci Educ 14, es4.

Brown JD (2009). Principal components analysis and exploratory factor analysis—definitions, differences and choices. Shiken JALT Testing & Evaluation SIG Newsl 13, 26–30.

Browne MW (2001). An overview of analytic rotation in exploratory factor analysis. Multivar Behav Res 36, 111–150.

Brownell SE, Tanner KD (2012). Barriers to faculty pedagogical change: lack of training, time, incentives, and tensions with professional identity? CBE Life Sci Educ 11, 339–346.

Bush SD, Pelaez NJ, Rudd JA, Stevens MT, Williams KS, Allen DE, Tanner KD (2006). On hiring science faculty with education specialties for your science (not education) department. Cell Biol Educ 5, 297–305.

Connell GL, Donovan DA, Chambers TG (2016). Increasing the use of student-centered pedagogies from moderate to high improves student learning and attitudes about biology. CBE Life Sci Educ 15, ar3.

Conover WJ, Iman RL (1981). Rank transformations as a bridge between parametric and nonparametric statistics. Am Stat 35, 124–129.

Couch BA, Wood WB, Knight JK (2015). The molecular biology capstone assessment: a concept assessment for upper-division molecular biology students. CBE Life Sci Educ 14, ar10.

Cronbach LJ (1951). Coefficient alpha and the internal structure of tests. Psychometrika 16, 297–334.

D'Avanzo C (2008). Biology concept inventories: overview, status, and next steps. BioScience 58, 2–7.

D'Avanzo C (2013). Post–*Vision and Change*: do we know how to change? CBE Life Sci Educ 11, 201–202.

Dolan E (2012). Next steps for *Vision and Change*: moving from setting the vision to change. CBE Life Sci Educ 11, 201–202.

Eddy SL, Converse M, Wenderoth MP (2015). PORTAAL: a classroom observation tool assessing evidence-based teaching practices for active learning in large science, technology, engineering and mathematics classes. CBE Life Sci Educ 14, ar23.

Elrod S, Kezar A (2014). Developing leadership in STEM fields: the PKAL summer leadership institute. J Leader Stud 8, 33–39.

Fabrigar LR, Wegener DT, MacCallum RC, Strahan EJ (1999). Evaluating the use of exploratory factor analysis in psychological research. Psychol Methods 4, 272–299.

Fortenbury J (2014). The perks of attending a liberal arts college. USA Today. http://college.usatoday.com/2014/02/24/the-perks-of-attending-a -liberal-arts-college (accessed 23 September 2015).

Frechtling JA, Merlino FJ, Stephenson K (2015). The call to transform postsecondary STEM educational practices and institutional policies. Am J Educ Stud 7, 27–42.

Freeman S, Eddy SL, McDonough M, Smith MK, Okoroafor N, Jordt H, Wenderoth MP (2014). Active learning increases student performance in science, engineering, and mathematics. Proc Natl Acad Sci USA 111, 8410–8415.

Henderson C, Beach A, Finkelstein N (2011). Facilitating change in undergraduate STEM instructional practices: an analytic review of the literature. J Res Sci Teach 48, 952–984.

Henderson C, Dancy MH (2011). Increasing the impact and diffusion of STEM education innovations. A white paper commissioned for the Characterizing the Impact and Diffusion of Engineering Education Innovations Forum, 7–8 February 2011. www.nae.edu/File.aspx?id=36304 (accessed 23 September 2015).

Hensel NH, Cejda BD (eds.) (2014). Tapping the Potential of All: Undergraduate Research at Community Colleges, Washington, DC: Council on Undergraduate Research. www.cur.org/assets/1/7/tapping_potential_final _web.pdf (accessed 10 December 2015).

Hotelling H (1933). Analysis of a complex of statistical variables into principal components. J Educ Psychol 24, 417–441498–520.

Jonasson A, Svingby G (2007). The use of scoring rubrics: reliability, validity and educational consequences. Educ Res Rev 2, 130–144.

Kaiser HF (1958). The varimax criterion for analytic rotation in factor analysis. Psychometrika 23, 187–200.

Kezar A (2009). Synthesis of scholarship on change in higher education. Cent High Educ Policy Analysis. A white paper commissioned for Mobilizing STEM Education for a Sustainable Future, meeting series held in 2009. http://mobilizingstem.wceruw.org/documents/synthesis%20 of%20scholarship%20on%20change%20in%20he.pdf (accessed 21 February 2016).

Kezar A (2001). Understanding and Facilitating Organizational Change in the 21st Century, ASHE-ERIC Higher Education Report 28, San Francisco, CA: Jossey-Bass, 147.

Kezar A, Gehrke S, Elrod S (2015). Implicit theories of change as a barrier to change on college campuses: an examination of STEM reform. Rev High Educ 38, 479–506.

Kuh GD (2008). Excerpt from High-Impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter, Washington, DC: Association of American Colleges and Universities. www.aacu.org/leap/hips (accessed 24 September 2015).

Labov JB (2012). Changing and evolving relationships between two- and four-year colleges and universities: They're not your parents' community colleges anymore. CBE Life Sci Educ 11, 121–128.

Momsen J, Offerdahl E, Kryjevskaia M, Montplaisir L, Anderson E, Nate Grosz N (2013). Using assessments to investigate and compare the nature of learning in undergraduate science courses. CBE Life Sci Educ 12, 239–249.

Nadelson LS, Southerland SA (2010). Development and preliminary evaluation of the measure and understanding of macroevolution: introducing the MUM. J Exper Educ 78, 151–190.

National Research Council (NRC) (2003). BIO2010, Transforming Undergraduate Education for Future Biologists, Washington, DC: National Academies Press. www.nap.edu/catalog/10497 (accessed 24 November 2015).

NRC (2011). Expanding Underrepresented Minority Participation: American's Science and Technology Talent at the Crossroads, Washington, DC: National Academies Press. www.nap.edu/read/12984 (accessed 24 November 2015).

National Science and Technology Council (2011). The Federal Science, Technology Engineering and Mathematics (STEM) Education Portfolio: A Report from the Federal Inventory of STEM Education Fast Track Action Committee on STEM Education. www.whitehouse.gov/sites/default/files/ microsites/ostp/costem__federal_stem_education_portfolio_report.pdf (accessed 24 November 2015).

National Science and Technology Council (2013). Federal Science Technology Engineering and Mathematics (STEM) Education 5-Year Strategic Plan. www.whitehouse.gov/sites/default/files/microsites/ostp/stem _stratplan_2013.pdf (accessed 24 November 2015).

Nilsen EA, Besterfield-Sacre M, Monroe-White T (2015). Landscape analysis as a tool in curricular change process. Paper presented at the Frontiers in Education Conference, 21–24 October 2015, in El Paso, TX. www .researchgate.net/publication/282158405_Landscape_Analysis_as_a_ Tool_in_the_Curricular_Change_Process (accessed 1 December 2015).

Pape-Lindstrom P, Jack T, Miller K, Aguirre K, Awong-Taylor J, Balser T, Brancaccio-Taras L, Marley K, Osgood M, Peteroy-Kelly M, *et al.* (2015). PULSE pilot certification results. J Microbiol Biol Educ 16, 127–129.

President's Council of Advisors on Science and Technology (2012). Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics. www .whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to -excel-final_feb.pdf (accessed 24 November 2015).

Russell S, Hancock MP, McCullough J (2007). Benefits of undergraduate research experiences. Science 316, 548–549.

Shi J, Wood WB, Martin JM, Guild NA, Vicens Q, Knight JK (2010). Diagnostic assessment for introductory molecular and cell biology. CBE Life Sci Educ 9, 453–461.

Smith JI, Tanner KD (2010). The problem of revealing how students think: concept inventories and beyond. CBE Life Sci Educ 9, 1–5.

Smith MK, Jones FHM, Gilbert SL, Wieman CE (2013). The classroom observation protocol for undergraduate STEM (COPUS): a new instrument to characterize university STEM classroom practices. CBE Life Sci Educ 12, 618–627.

Smith MK, Wood WB, Knight JK (2008). The Genetics Concept Assessment: a new concept inventory for gauging student understanding in genetics. CBE Life Sci Educ 7, 422–430.

Suchman EL (2014). Changing academic culture to improve undergraduate STEM education. Trends Microbiol 22, 657–659.

Suhr D (2005). Principal component analysis vs. exploratory factor analysis. SUGI 30 Proceedings.

Talanquer V (2014). DBER and STEM education reform: are we up to the challenge? J Res Sci Teach 51, 809–819.

U.S. Congress Joint Economic Committee (2012). STEM Education: Preparing for the Jobs of the Future. www.jec.senate.gov/public/_cache/files/6aaa7e1f-9586-47be-82e7-326f47658320/stem-education-preparing-for-the-jobs-of-the-future-.pdf (accessed 24 September 2015).

Vilorio D (2014). STEM 101: intro to tomorrow's jobs. Occup Outlook Q. www.bls.gov/careeroutlook/2014/spring/art01.pdf (accessed 10 December 2015).

Watkins J, Mazur E (2013). Retaining students in science, technology, engineering, and mathematics majors. J Coll Sci Teach 42, 36–41.

Wei CA, Woodin T (2011). Experiences in biology: alternatives to the apprenticeship model. CBE Life Sci Educ 10, 123–131.

Wieman C (2007). Why not try a scientific approach to science education? Change 39, 9–15.

Wieman C (2014). Large-scale comparison of science teaching methods sends clear message. Proc Natl Acad Sci USA 111, 8319–8320.

Wieman C, Gilbert S (2014). The Teaching Practices Inventory: a new tool for characterizing college and university teaching in mathematics and science. CBE Life Sci Educ 13, 552–569.

Wieman C, Perkins K, Gilbert S (2010). Transforming science education at large research universities: a case study in progress. Change 42, 6–14.

Woodin T, Fesser J, Herrera J (2012). The vision is set, now help chronicle the change. CBE Life Sci Educ 11, 347–350.

Supplemental Material

Brancaccio-Taras *et al.*

THE PULSE VISION & CHANGE RUBRICS Version 1.1

Partnership for Undergraduate Life Sciences Education (PULSE) is a collaborative effort developed and funded by NSF, NIH/NIGMS, and HHMI to catalyze adoption of the principles outlined in the 2011 report *Vision and Change in Undergraduate Life Science Education: A Call to Action.* The PULSE Steering Committee selected 40 current and former life science department chairs or deans to serve as Vision & Change Leadership Fellows from September 2012-September 2013. One working group of Fellows, referred to as "Taking the PULSE", developed the PULSE Vision & Change Rubrics during the fellowship year.

The PULSE Vision & Change Rubrics articulate fundamental criteria for evaluating the level of adoption of the principles of *Vision and Change* in life science departments. The rubric descriptors designate different levels of adoption of *Vision & Change* principles from first steps to full departmental transformation. The rubrics initially can provide a structure for departmental reflection and self-assessment and discussion regarding a host of topics relevant to program transformation. The utility of the PULSE Vision & Change Rubrics is to provide a basic framework of expectations, such that evidence of adoption of *Vision & Change* principles can be gathered and self-assessed by departments and a roadmap for continued transformation can be plotted. Ultimately, the rubrics are intended to serve as the basis for a tiered certification program for undergraduate life science departments that have adopted some or all of the principles outlined in the *Vision & Change* report and a blueprint for change in departments that have not yet adopted those principles. These rubrics are designed for flexible use by undergraduate life science departments at a broad range of institution types including two-year colleges, four-year liberal arts institutions, regional comprehensive institutions and research institutions. The core expectations articulated in the PULSE Vision & Change Rubrics can and should be translated into the language of individual departments and institutions, in order to evaluate and expedite departmental transformation in the context of each institution. An institution of any type should be able to achieve each level of certification.

We also anticipate that the rubrics could be used in STEM departments of all types with some modifications, particularly to concepts and competencies specific for life sciences. However, most of the rubric criteria are robust and could apply broadly to the range of STEM disciplines.

SCOPE OF THE RUBRICS

Multi-component rubrics have been developed that can assess department or program alignment with *Vision & Change* recommendations in five areas: Curriculum Alignment, Assessment, Faculty Practice/Faculty Support, Infrastructure, and Climate for Change. Each rubric has several categories with multiple criteria to be assessed. Although many of the scoring criteria are clear, we realize that some criteria may require more explanation, definition of terms, and specific examples to make them comprehensible. At present, we are working on assembling a detailed instruction manual to aid in use of the rubrics. Points are assigned for the levels of achievement in each category. Ultimately each rating criterion will be weighted to reflect the significance of the criterion for program transformation. The weighting will be established through a series of pilot certifications in 2014 (pending funding) and feedback is welcome.

CURRICULUM ALIGNMENT RUBRIC (11 criteria)

This rubric considers the degree to which the curriculum in a Life Sciences program addresses the core concepts for biological literacy and core competencies and disciplinary practice outlined in *Vision & Change*. This rubric has rating criteria for each core concept and core competency providing programs the opportunity to evaluate the integration of these ideas and skills into their curriculum. Most of these criteria are specific to Life Science education and *Vision & Change*, although many of the competencies would be applicable to other STEM fields.

ASSESSMENT RUBRIC (12 criteria)

This rubric addresses the degree to which programs have developed and employ curricular and course learning goals/objectives for students, and have developed and use assessments that are aligned with learning outcomes desired for students at both the course and whole curriculum level. There are two major rating categories, Course-Level Assessment and Program-Level Assessment. Only one criterion is specific to Life Science education and *Vision & Change*; all other criteria would be relevant to any STEM discipline.

FACULTY PRACTICE/FACULTY SUPPORT RUBRIC (21 criteria)

This rubric considers *Vision & Change* implementation issues that primarily are driven by or affect faculty. Overall, there are three main categories including Student Higher Level Learning, Learning Activities Beyond the Classroom, and Faculty Development with 5-10 rating criteria in each category. The Student Higher Level Learning category evaluates faculty efforts and student willingness to reflect on and engage in activities and processes that require higher level cognitive efforts. The category on Learning Activities Beyond the Classroom evaluates the range of opportunities and support mechanisms available to students. The Faculty Development category evaluates the support for faculty within the department and institution that enables them to learn and practice the recommendations of *Vision & Change* and scientific teaching principles. The term "faculty" in this rubric can and should include all applicable appointments including graduate teaching assistants, post-doctoral fellows, adjunct faculty and full time faculty. Also included in this category is recognition of the importance of effective teaching in yearly review, promotion and tenure decisions. The criteria included in this rubric would be broadly applicable to other STEM disciplines.

INFRASTRUCTURE RUBRIC (12 criteria)

This rubric deals with institutional infrastructure issues that facilitate *Vision & Change* implementation. There are three main categories in this rubric: Physical Infrastructure, Learning Spaces, and Resources and Support. The criteria in the Physical Infrastructure category assess the quality of the physical teaching spaces, and the degree to which they enable innovative teaching practices consistent with *Vision & Change*. Criteria in the Learning Spaces category assess whether informal learning spaces and Learning Center spaces are available on campus. The criteria in the Resources and Support category assess various types of staff support for teaching, including administrative assistants, laboratory instructors, and IT specialists. The accessibility of electronic resources is also considered under Resources and Support. The criteria included in this rubric would be broadly applicable to other STEM disciplines.

CLIMATE FOR CHANGE RUBRIC (11 criteria)

This rubric assesses the institution, administrative and department openness to and movement toward the type of change outlined for life sciences education in *Vision & Change*. Categories examine Administrative and Institutional Vision, Attitude and Action, as well as Departmental Support for administrative change efforts. There are 2-3 rating criteria in each category and while many of these criteria are out of the control of departmental faculty, they are critical for transformation and sustainability of reformed efforts in life sciences education.

To download the rubrics and for questions or feedback on the rubrics or the developing certification program, please contact the Taking the PULSE working group at http://www.pulsecommunity.org or the individuals listed below:

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CURRICULUM ALIGNMENT

	Factors	Weight	0 (not observed)	1 (initial stages)	2 (average)	3 (very good)	4 (excellent, exemplar)	Final Score
A. CORE CONCEPTS								0
1	**Evolution core concept integrated into curriculum**		Concept not included in any courses	Students are only minimally exposed to this concept	Students are exposed to this concept in significant detail in at least one required course	Students are exposed to this concept in significant detail in at least one course and implicit understanding is expected in additional courses	Students get multiple opportunities to explore this concept in order to complete their degree	
2	**Structure and function core concept integrated into curriculum**		Concept not included in any courses	Students are only minimally exposed to this concept	Students are exposed to this concept in significant detail in at least one required course	Students are exposed to this concept in significant detail in at least one course and implicit understanding is expected in additional courses	Students get multiple opportunities to explore this concept in order to complete their degree	
3	**Information flow, exchange and storage core concepts integrated into curriculum**		Concept not included in any courses	Students are only minimally exposed to this concept	Students are exposed to this concept in significant detail in at least one required course	Students are exposed to this concept in significant detail in at least one course and implicit understanding is expected in additional courses	Students get multiple opportunities to explore this concept in order to complete their degree	
4	**Pathways and transformations of energy and matter core concept integrated into curriculum**		Concept not included in any courses	Students are only minimally exposed to this concept	Students are exposed to this concept in significant detail in at least one required course	Students are exposed to this concept in significant detail in at least one course and implicit understanding is expected in additional courses	Students get multiple opportunities to explore this concept in order to complete their degree	
5	**Systems core concept integrated into curriculum**		Concept not included in any courses	Students are only minimally exposed to this concept	Students are exposed to this concept in significant detail in at least one required course	Students are exposed to this concept in significant detail in at least one course and implicit understanding is expected in additional courses	Students get multiple opportunities to explore this concept in order to complete their degree	

CURRICULUM ALIGNMENT

	Factors	Weight	0 (not observed)	1 (initial stages)	2 (average)	3 (very good)	4 (excellent, exemplar)	Final Score
B. INTEGRATION OF CORE COMPETENCIES								
1	**Integration of the process of science into the curriculum**		Competency is not included in any courses	Students are only minimally exposed to this competency	Students are exposed to this competency in significant detail in at least one required course	Students are exposed to this competency in significant detail in at least one course and implicit understanding is expected in additional courses	Students get multiple opportunities to explore this competency in order to complete their degree	
2	**Integration of quantitative reasoning into the curriculum**		Competency is not included in any courses	Students are only minimally exposed to this competency	Students are exposed to this competency in significant detail in at least one required course	Students are exposed to this competency in significant detail in at least one course and implicit understanding is expected in additional courses	Students get multiple opportunities to explore this competency in order to complete their degree	
3	**Integration of modeling and simulation into the curriculum**		Competency is not included in any courses	Students are only minimally exposed to this competency	Students are exposed to this competency in significant detail in at least one required course	Students are exposed to this competency in significant detail in at least one course and implicit understanding is expected in additional courses	Students get multiple opportunities to explore this competency in order to complete their degree	
4	**Integration of the interdisciplinary nature of science into the curriculum**		Competency is not included in any courses	Students are only minimally exposed to this competency	Students are exposed to this competency in significant detail in at least one required course	Students are exposed to this competency in significant detail in at least one course and implicit understanding is expected in additional courses	Students get multiple opportunities to explore this competency in order to complete their degree	
5	**Communication and collaboration through a variety of formal and informal written, visual, and oral methods integrated into curriculum**		Competency is not included in any courses	Students are only minimally exposed to this competency	Students are exposed to this competency in significant detail in at least one required course	Students are exposed to this competency in significant detail in at least one course and implicit understanding is expected in additional courses	Students get multiple opportunities to explore this competency in order to complete their degree	
6	**An understanding of the relationship between science and society is embedded into the curriculum**		Competency is not included in any courses	Students are only minimally exposed to this competency	Students are exposed to this competency in significant detail in at least one required course	Students are exposed to this competency in significant detail in at least one course and implicit understanding is expected in additional courses	Students get multiple opportunities to explore this competency in order to complete their degree	

ASSESSMENT

	Factors	Weight	0 (not observed)	1 (initial stages)	2 (average)	3 (very good)	4 (excellent, exemplar)	Final Score
A. COURSE LEVEL ASSESSMENT								0
1	**Learning outcomes are well written and clearly related to core concepts and competencies**		Learning outcomes are not related to core concepts and competencies	Learning outcomes are not clearly related to concepts and competencies	Learning outcomes are somewhat related to concepts and competencies	Learning outcomes are well written and are mostly related to concepts and competencies	Learning outcomes are well written and clearly related to concepts and competencies	
2	**Learning outcomes are explicitly presented in the courses**		Learning outcomes are not explicitly presented	Learning outcomes are explicitly presented in the syllabus but not discussed with students during the course	Learning outcomes are explicitly presented in syllabus along with an explanation of how outcomes will be measured during course	As in level 2; in addition outcomes and their measurements are discussed with students	As in level 3; in addition outcomes and their measurements are discussed with students numerous times during the course	
3	**Assessments linked to learning outcomes**		Assessments are not linked to learning outcomes	Some courses have assessments that measure learning outcomes	Many courses have assessments that measure learning outcomes	The majority of courses have assessments that measure learning outcomes	The majority of courses have assessments that clearly measure learning outcomes	
4	**Instructor-independent assessment tools are utilized**		No assessment tools are instructor independent	Less than 25% of assessment tools used are instructor independent but are generated within the department	At least 25% of assessment tools used are instructor independent but are generated within the department	At least 50% of assessment tools used are instructor independent and include some that are generated external to the department	At least 75% of assessment tools used are instructor independent with many generated external to the department	
5	**Course quality evaluation includes assessing time in student-centered activities**		Time spent in student-centered activities is not measured	Time spent in student-centered activities is informally estimated at the end of semester/quarter	Time spent in student-centered activities is documented by approximation after the fact in formal course quality evaluation at the end of semester/quarter	Time spent in student-centered activities is informally tracked at periodic points throughout the semester/quarter and reported in formal course quality evaluations at end of semester/quarter	Time spent in student-centered activities is formally documented at periodic points throughout the semester/quarter and reported in formal course quality evaluation at end of semester/quarter	
6	**Use assessment pre- and post-instruction to measure effectiveness of instructional approaches**		No assessment	Less than 25% of courses include pre- or post-instruction assessments	25-50% of courses include pre- or post-instruction assessments	51-75% of courses include pre- and post-instruction assessments	More than 75% of courses include pre- and post- instruction assessments	
7	**Evidence of student preparedness and interests are used to inform curricular changes that reflect student preparedness and interest**		No evidence is collected or used to inform curricular change	Less than 50% of instructors report occasionally using anecdotal reports	Instructors are encouraged to conduct regular surveys and/or assessments, at least 50% of instructors survey/assess their students but results are not used when planning curricular changes	All characteristics listed for a score of 2 are present but results are consulted in planning curricular changes and real world examples are aligned with student preparedness and interest; progress is reported annually	All characteristics listed for a score of 3 are present, at least 75% of instructors survey/assess their students, instructors track and report progress annually which is rewarded during annual performance review	

ASSESSMENT

	Factors	Weight	0 (not observed)	1 (initial stages)	2 (average)	3 (very good)	4 (excellent, exemplar)	Final Score
B. PROGRAM LEVEL ASSESSMENT								
1	**Assessment of six V&C competencies at the program level**		Competencies not assessed at the program level	Development of at least one of the competencies assessed	Development of 2-3 competencies assessed	Development of 4-5 competencies assessed	Development of all 6 V&C competencies assessed	
2	**Direct and indirect data on program effectiveness are collected and analyzed; the results are used to strengthen programs**		Overall program effectiveness is not assessed	Data collected but results are not used for improving the program	Data collected, results are used to try to improve the program but resulting change is not tracked	Data collected with clear purpose, and continual dialog regarding the results is is used to guide efforts to improve the program but resulting change is not tracked	Data collected with clear purpose, and continual dialog regarding the results is used to guide efforts to improve the program, resulting changes are identifiable and measured	
3	**Assess retention of all kinds of students in the program**		Retention is not evaluated	Retention is measured only with enrollment figures	Retention is measured with enrollment figures as well as with attention to student populations of special interest	Retention is measured as for 2 but also includes students at critical transition points	Data collected as for 3; data are critically analyzed	
4	**Retention assessment data are used for improving student retention**		Data are not used	Data are collected but are not used in any clear way	Data are used in a coordinated capacity to improve retention	Data are used in a coordinated and consistent way across the areas of the program to improve retention	Data are used in a coordinated and consistent way with strategies implemented and assessed for levels of success	
5	**Use assessments as tools to identify whether there are differences in learning outcomes and the nature of these differences among different student populations (e.g. women and under-represented minority students)**		No effort made to identify differences	Assessments provide suggestions of differences, but no efforts are made to use the information to develop strategies to address achievement gaps	Assessments provide suggestions of differences, information discussed and used informally to address achievement gaps	Assessments provide suggestions of differences, formal interventions developed to address achievement gaps	Assessments provide suggestions of differences; interventions developed to address achievement gaps; achievement gaps between various segments of student body measured to assess the impact of interventions on	

FACULTY PRACTICE/FACULTY SUPPORT

	Factors	Weight	0 (not observed)	1 (initial stages)	2 (average)	3 (very good)	4 (excellent, exemplary)	Final Score
A. STUDENT HIGHER LEVEL LEARNING								0
1	**Exposure to inquiry-based, open-ended research and interpretation in course labs: guided inquiry or research that requires hypothesis generation/data interpretation**		All laboratory experiments have known outcomes ("cookbook labs")	Exposure is limited; <50% of students are not exposed	Inquiry modules are used a large fraction of lab courses; more than 70% of students are exposed	Inquiry modules are included in the majority of course labs. Every student has at least one exposure; Some students have several exposures	Inquiry is the norm in most labs. Students are accustomed to formulating questions and interpreting findings	
2	**Exposure to inquiry, ambiguity, analysis and interpretation in non-lab courses**		Most courses do not provide such opportunities; student have little exposure	25% or less of courses have such opportunities; a subset of students are exposed	Class sessions/ assignments in ~25-50% of courses have multiple opportunites; many student are exposed	Greater than 50% of courses have opportunities, most students are exposed	Such opportunities are the norm in courses; all student are exposed, many get multiple exposures	
3	**Instructors encourage/teach student metacognition: instructors guide students to reflect on their learning styles and understand how to use learning strategies that are supported by cognitive research**		Instructors do not encourage student metacognition	<25% of Instructors discuss and encourage effective learning strategies	25-50% of instructors discuss and encourage effective learning strategies	Students in >50% of courses are encouraged to reflect, and some instructors integrate practice of effective strategies within assignments	Instructors routinely intentionally integrate practice of effective strategies within assignments	
4	**Students' Metacognitive Knowledge: students reflect on their learning styles and understand and use learning strategies that are supported by cognitive research**		Students are unreflective and lack awareness or understanding	Students rarely reflect on styles and have only minimal knowedge	Most students have some awareness, but many lack the knowledge to effectively use	Most students have some awareness; many have the knowledge to employ	Students are adept at using strategies to improve learning outcomes for self and peers.	
5	**Students Practice Higher-Order Cognitive Processes**		Students use only lowest-level cognitive processes (memorization/ recall) across the curriculum. Instructors are not aware and/or not encouraged to reflect on cognitive level of tasks	Students' cognitive processes remain at lower levels but may include understanding and application in addition to recall. Typically there is no organized effort among instructors to distinguish cognitive level of tasks	A small proportion of students (<25%) in specialized, upper-level courses are challenged to use higher-order cognitive processes (e.g., synthesize, evaluate, create). A few instructors may be leading efforts to move students to higher-order cognition	Higher-order cognitive processes are practiced by students at all course levels, but such practice is not yet ubiquitous across all courses, and not all instructors are adept at developing tasks for student practice at these higher levels	Students regularly work at higher cognitive levels in most courses, and instructors are adept at developing assignments and exams for practice at each level	

FACULTY PRACTICE/FACULTY SUPPORT

	Factors	Weight	0 (not observed)	1 (initial stages)	2 (average)	3 (very good)	4 (excellent, exemplary)	Final Score
B. LEARNING ACTIVITIES BEYOND THE CLASSROOM								
1	**Availability of intramural and/or Extramural Mentored Research: Student opportunities**		No opportunities exist	Limited opportunities available; <25% of students can be accommodated	26-50% of students can be accommodated	51-75% of students can be accommodated	>75% of students can be accommodated	
2	**Availability of intramural and/or Extramural Mentored Research: Student exposure, % of students who graduate with one or more summer/semester of mentored research**		No students participate in mentored research.	<15% students participate	16-30% students participate	31-60% students participate	>60% students participate	
3	**Advisors and formal programs encourage and support student participation in research by proactively helping students find opportunites and understand the value through activites that schowcase student research**		No support mechanisms	Minimal informal support	Proactive informal support	Formal program and some informal mechanisms	Extensive programming and other mechanisms promote and support	
4	**Instructors available and welcoming beyond classroom/lab hours; instructors interested in student success**		Instructors not available	Instructors available, but >50% are perceived as distant, unresponsive	>50% of the instructors are perceived as available and welcoming	>75% of instructors perceived as available, welcoming, supportive	All instructors perceived as available, approachable, helpful, and supportive	
5	**Opportunities for supplemental student engagement for thriving in STEM are provided, such as tutoring, peer mentoring, advising, interest-based clubs, internships, etc**		Supplemental engagement methods are absent	Supplemental engagement opportunities are minimal (e.g., one or two methods; few students offered opportunities)	Supplemental engagement methods are diverse, but only offered to a small subset of students	Supplemental enagement methods are diverse and widely available	All of level three criteria are met; Supplemental engagement methods are promoted by course instructors	
6	**Student participation in supplemental student engagement opportunities**		Supplemental engagement opportunties utilized by <10% students	Supplemental engagement opportunties utilized by less than 25% of students	Supplemental engagement opportunties utilized by 26- 50% of students	Supplemental engagement opportunties utilized by 51-75% of students	Supplemental engagement opportunties utilized by >75% of students	

FACULTY PRACTICE/FACULTY SUPPORT

	Factors	Weight	0 (not observed)	1 (initial stages)	2 (average)	3 (very good)	4 (excellent, exemplary)	Final Score
C. FACULTY DEVELOPMENT								
1	**Awareness of National Efforts in Undergraduate STEM Education Reform**		Instructors isolated from the national dialogue	Pockets of awareness of need for reform and national efforts exist	50% of the faculty aware of reform and national efforts	75% of the faculty aware of reform and national efforts	Awareness of the need for reform and national efforts is widespread	
2	**Faculty Attendance at meetings and workshops related to Life Science education reform**		Faculty do not attend conferences or workshops related to reform	Small fraction of instructors (<10%) have opportunity or desire to attend national meetings. Usually pay own expenses to such meetings	Cadre of instructors (25%) attend national meetings and workshops; limited financial support available	A large number (50%) of instructors attend national conferences and/or on-campus workshops, typically with financial support	>75% of instructors regularly participate in workshops and dialogue on STEM reform. Instutional support exists for attendance at conferences, etc	
3	**Awareness/ Implementation of Discipline-based Education Research (DBER)**		Faculty are unaware of DBER and its utility	A small subset of faculty is aware of DBER findings and use this information to inform class practice	At least 25% of the instructors are aware of and use DBER findings	At least 50% of the instructors are aware of and use DBER findings	At least 75% instructors are aware of and use DBER findings	
4	**Sharing of information about evidence-based and effective pedagogy**		No sharing of pedagogical methods, data about effective teaching practices with colleagues	There is little sharing of ideas data and techniques with colleagues	At least 25% of instructors regularly share ideas and techniques	At least 50% of instructors regularly share ideas and techniques	At least 75% of instructors regularly share ideas and techniques. Some formalized discussion groups exist	
5	**Pedagogical Approaches Reflect Best Practices**		Lecturing without student engagement is dominant practice in all life science courses.	Traditional lectures interspersed with student responses to prompts (e.g., < 25% of time students are engaged). More engaging pedagogies used by one or few instructors	A core group of practitioners is shifting department's attitudes and practices toward more widespread use of engaging pedagogies	All instructors are learning about and attempting to adopt best pedagogical practices, although reverting to lecturing for more than 25% of classtime is common	Students rarely sit passively listening to lectures. Students are engaged in discussion, guided inquiry, and other activities in class and lab	

FACULTY PRACTICE/FACULTY SUPPORT

	Factors	Weight	0 (not observed)	1 (initial stages)	2 (average)	3 (very good)	4 (excellent, exemplary)	Final Score
C. FACULTY DEVELOPMENT								
6	**Instructors Pursue Shared Learning Goals**		Learning goals (concepts, competencies, & dispositions) are unknown/not articulated.	Learning goals are vague or are professed in static documents, but they are not pursued with intentionality nor are they apparent to students	Learning goals are written (e.g., department web page), but goals are not readily apparent to students nor consistantly pursued by all instructors	Learning goals are clearly documented (e.g., course syllabi) and discussed with students. However, not all instructors have mastered matching assignments and student practices to achieve goals	Learning goals are clear and intentionally pursued in courses across curriculum, courses are constructed to achieve goals, assignments give practice in learning outcomes, all syllabi reflect goals	
7	**Support for Teaching/Learning Needs in STEM**		No formal support, such as Teaching and Learning Center (T&L Center)	T&L Center or other formal support available but programming limited and awareness of STEM education needs also limited	T&L Center or other formal programming is broad in scope but does not address particular needs of STEM faculty	T & L Center or similar structure supports STEM faculty with customized workshops for STEM teaching and learning	T&L Center or similar structure offers responsive programming that includes workshops and consultation to meet the needs of STEM faculty; Center reaches out to STEM faculty	
8	**Faculty orientation and mentoring for teaching role**		Instructors receive no formal orientation to institutonal or departmental policies and practices. Mentoring of any type is informal if present	Mandatory, single-session orientation for new facutly/staff to institution includes little or no orientation to development of scientific teaching. If present, mentoring for teaching is informal and rarely includes adjunct instructors	Orientation includes additional informal gatherings around development of teaching skills for first-year instructors (optional for adunct instructors). Formal mentoring occasionally includes pedagogy	Multiple, formal orientation sessions around teaching are mandatory for new faculty/staff, including adjuncts, throughout the first year. Designated formal mentor is well-versed in pedagogy	All of conditions to achieve a score of 3 exist; in addition, on-going institutional/ departmental discussions around teaching encourage continuing effort to learn throughout the pre-tenure period	
9	**Institutional support for faculty course development**		Course development/ renovation is not recognized as an important activity; such work is discouraged; no impact on load	Course development/ renovation is not recognized as an important activity, but not actively discouraged; no impact on load	Course development/ renovation is recognized as an important activity; no impact on load	Course development/ renovation is recognized as an important activity; reduced load is granted	All the conditions to achieve 3 are present; faculty are ecouraged to experiment and given flexibility to design pilots	
10	**Institutional support for faculty training in emerging areas**		Faculty are discouraged from taking time for such training	Faculty who participate in such training do so without financial support	Faculty who participate in such training can request support; occasionally granted	Faculty who participate in such training can request support; frequently granted	The department/ institution has funds designated for such activities and faculty are encouraged to use it	

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INFRASTRUCTURE

	Factors	Weight	0 (not observed)	1 (initial stages)	2 (average)	3 (very good)	4 (excellent, exemplary)	Final Score
A. PHYSICAL INFRASTRUCTURE								0
1	**Classrooms and teaching laboratories can accommodate special needs and differing abilities**		None of the classrooms serve students with diverse needs.	<10% of assigned classrooms comply, very limited ability to serve students with diverse needs	10-25% of assigned classrooms comply	26-75% of assigned classrooms comply	>75% of assigned classrooms comply	
2	**Access to flexible, re-configurable teaching spaces to encourage student interaction, ability to work in small groups**		All assigned classrooms are lecture style with fixed seating	< 10% of assigned classrooms are flexible and reconfigurable	10-50% of assigned classrooms are flexible and reconfigurable	50-75% of classrooms are flexible and reconfigurable; different types of classrooms are available for diverse teaching styles	>75% of classrooms are flexible and reconfigurable; different types of classrooms are available for diverse teaching styles	
3	**Classroom IT infrastructure to encourages active-learning practices**		All assigned classrooms have no IT technology	< 10% of assigned classrooms have at least one IT resources for active learning purposes	10-50% of assigned classrooms have at least one resource for active learning purposes	10-50% of assigned classrooms have at least two IT resources for active learning purposes	More than 50% of assigned classrooms have at least two IT resources for active learning purposes	
4	**Access to intelligently-designed laboratory space flexible enough to allow different uses that blur distinction between lecture and lab**		Laboratories are antiquated (possibly dangerous); prep and equipment space is not separated	<10% of laboratories are well designed with prep and equipment space separated	10 - 50% of laboratories are well designed with prep and equipment space separated; IT resources available	51 - 75% of laboratories are well designed with prep and equipment space separated; IT resources available	76% - 100% of all laboratories are well designed with prep and equipment space separated; IT resources available	
5	**Equipment/supplies in teaching laboratories**		Limited laboratory equipment available to students, >90% of equipment is old or antiquated, supplies for laboratories are very limiting	>25% of equipment is new, equipment is available for student use but not enough equipment for the student load, supplies for laboratories are limiting	>50% of equipment is new, equipment is comes close to meeting the student load, supplies for laboratories are adequate	51 - 75% of equipment is new, amount ouf available equipment matches the student load, supplies for laboratories are adequate	>75% of equipment is new, amount ouf available equipment matches the student load, supplies for laboratories are adequate	

INFRASTRUCTURE

	Factors	Weight	0 (not observed)	1 (initial stages)	2 (average)	3 (very good)	4 (excellent, exemplary)	Final Score
B. LEARNING SPACES								
1	**Informal gathering spaces that encourage collaboration**		Informal gathering space not available	A space is available but not located near labs, classrooms, or faculty offices - use is not encouraged	A space is available but not located near labs, classrooms, or faculty offices; use is encouraged by administation	Several good spaces are available; at least one is near labs, classrooms, or faculty offices; use is encouraged by administation	Several good spaces are available; all are near labs, classrooms, or faculty offices; use is encouraged by administation	
2	**Learning Center for Students - for example, college-wide writing centers, learning centers or dept. level center with staff, tutor meeting rooms, TAs, computers and printers, study space for students**		None	Facility available; no staff; limited range of options; limited hours	Staffed facility available; limited range of options; limited hours	Facility available; multiple staff members (overseer, tutors), addressing multiple student needs (writing, math, bio); extended hours; multiple breakout rooms available	All characteristics listed for a score of 3 are present; also staffed with learning specialist; open most of the time to meet students needs	
C. RESOURCES AND SUPPORT								
1	**IT support for innovative teaching, responds quickly to IT crisis; support includes hands-on technology training for faculty and proactive survey of new technology**		No IT support	IT staff provides limited support; faculty are not satisfied with level of support when issues arise	IT staff provide support adequate to meet faculty needs when issues or problems arise	All characteristics listed for a score of 2 are present, in addition IT staff provide hands-on training	All characteristics listed for a score of 3 are present; proactive IT staff also suggest innovative technologies	
2	**Staff support for teaching: administrative help to support teaching, lab managers/lab instructors, curriculum development/learning specialists, tenure-track faculty with education specialty**		No staff support for faculty	Very limited support, e.g. part time administrative support or part-time lab support help	A minimum of the equivalent of one full time position dedicated to teaching support	Adequate administrative and lab managers/instructor support provided. Department has _either_ a curriculum development position or biology education-based tenure-track faculty position	Adequate administrative and lab managers/instructor support provided. Department has _both_ a curriculum development position or biology education-based tenure-track faculty position	
3	**Institutional support for electronic resources, e.g. journal subscriptions and databases**		No institutional subscriptions available	Very limited subscriptions available, only to top journals (e.g. _Nature_ , _Science_ , _PNAS_)	Subscriptions extend to the top journals in each subfield (e.g _Ecology_ , _Journal of Cell Biology_ , _Nature Genetics_ etc.), but specialty journals offerings are limited	Subscriptions extend to some specialty journals in selected subfields. But it is still common that articles that faculty and students require are not freely available	Wide range of electronic journals, databases are available for use by faculty and students without fee. Rare that a journal article cannot be freely obtained	

CLIMATE FOR CHANGE

	Factors	Weight	0 (not observed)	1 (initial stages)	2 (average)	3 (very good)	4 (excellent, exemplar)	Final Score
A. ADMINISTRATIVE AND INSTITUTIONAL VISION								0
1	**Vision is clear and specific**		Administrative vision has not been written	Administrative vision is written, but uses vague or unclear language; department members do not understand or are not aware of the vision	Administrative vision is written, uses clear language, and department members express basic awareness and/or understanding of the vision	Components of 2 are present and vision has been distributed amongst dept. members and discussed. Feedback on feasibility and innovativeness have been collected from dept. members	Components of 3 are present and feedback has been incorporated into a new vision statement that is clear, innovative, and feasible	
2	**Vision aligns with V&C priorities**		Vision is not aligned with V&C priorities	Vision is aligned with 25% of less of the V&C priorities	Vision is aligned with 25-50% of the V&C priorities	Vision is aligned with 50-75% of V&C priorities	Vision is aligned with 75% or more of V&C priorities	
3	**Commitment to vision is demonstrated through administrative action**		No discussion of the implementation of the vision occurs	Casual discussion occurs about implementing the vision but no action items chosen	Casual discussion of how to implement the vision occurs and action items chosen but not followed through	Formal discussion of how to implement the vision occurs and all important players attend; action items are chosen and followed through but not formally recorded	Components of 3 are present plus formal recording/monitoring system exists for following up with delegated activities	
B. ADMINISTRATIVE AND INSTITUTIONAL ATTITUDE								
1	**Administration is supportive of the need for change**		Admin. expresses resistance to change, such as change items not included on meeting agendas, no funding support for change towards national initiatives, faculty report feelings of hostility from admin. regarding discussion of changing practices; difficulty in attaining meetings with admin. officials to discuss change	Administration does not openly express resistance to change, but avoids discussion of change by not supporting opportunities to discuss change; change items may be included in meeting agendas but not actively discussed/no action items taken	Administration verbally expresses support for change but does not put financial or other resources towards doing so (i.e. requires change to be sought out by individual faculty)	Administration verbally expresses support of change and provides some, but not enough, financial resources towards change and/or only some faculty are able to secure these resources	Administration is verbally and financially supportive of change initiatives across the entire department	
2	**There is awareness and buy-in of national initiatives in higher education**		Administration does not recognize/is not aware of national initiatives	Administration is aware of national initiatives, but no action is taken	Administration is aware of national initiatives and takes observable action to promote initiatives on occasion, but no long-term plan or funding is in place	Administration is aware of national initiatives and takes observable action to promote initiatives on a regular basis and/or short-term action plan is in place	Components of 3 are present and admin. allocates resources and establishes a long-term action plan	
3	**Institutional evaluation and assessment reflects the importance of teaching**		No institutional evaluation and assessment of learning gains and teaching portfolios	Institutional recognition of the need to evaluate and assess learning gains and teaching portfolios, but nothing formal available for departments	Faculty/departmental levels assessments of learning gains and teaching portfolios conducted but not aggregated at an institutional level	Institutional data includes assessments of learning gains and teaching portfolios conducted at the faculty/departmental level but not consistent in measurement across the institution	Institutional data includes consistent, formal in-depth assessments of learning gains and teaching portfolio aggregated at the institutional level	

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CLIMATE FOR CHANGE

	Factors	Weight	0 (not observed)	1 (initial stages)	2 (average)	3 (very good)	4 (excellent, exemplar)	Final Score
C. ADMINISTRATIVE AND INSTITUTIONAL ACTION								
1	**Strategies are in place to recruit and retain diverse teaching faculty**		No active strategy for recruiting diverse teaching faculty either informally or formally	The need to recruit and retain diverse teaching faculty is mentioned informally as important, but no formal action is taken	Formal action is taken to seek diverse candidates, search committee chairs and department chairs are trained on how diversity is supported at the institution	Components of 2 are present and resources are provided to incentivize hiring diverse teaching faculty, candidates are exposed to the diversity on campus when they visit	Components of 3 are present and a process exists to measure success in recruitment and retention of diverse teaching faculty, diverse teaching faculty have achieved success via promotion	
2	**Faculty incentives exist for transformative approahces in teaching**		No incentives exist for faculty to be rewarded for creative teaching and some barriers exist	Informal recognition (i.e. email praise) exists but is rare and infrequent for faculty who teach in creative ways	Informal recognition is common for all faculty who teach in creative ways, formal awards exist that consider or emphasize a faculty's teaching merit; transformative teaching methods are mentioned but not heavily weighted in annual review, promotion and tenure (P&T)	Components of 2 are present and several formal awards exist for recognizing innovative teachers, transformative teaching methods and the scholarship of teaching and learning are actively considered in P&T	Components of 3 are present, transformative teaching methods and scholarship of teaching and learning are actively considered/weighted in P&T and this is widely understood throughout the department	
3	**Resources exist for faculty to improve their teaching methods**		Resources are not available for faculty to improve their teaching methods	Some resources are available for faculty to improve teaching methods but are widely unknown and unused by faculty	Resources exist for improving teaching methods, and are used by a minority of the faculty; all faculty are aware resources exist	Components of 2 are present and resources are actively distributed, disseminated, or paid for by department leaders to improve faculty's teaching methods	Components of 3 are present and nearly all faculty use these resources and are aware resources exist	
4	**Fundraising and development efforts support departmental transformation in alignment with V&C**		Fundraising efforts are not aligned with V&C	Fundraising efforts aligned with V&C derive only from individual faculty members	There is at least one fundraising effort in support of V&C at the department level	There are fundraising efforts in support of V&C at the department level and a discussion of fundraising at the institutional level	There are successful fundraising efforts in support of V&C at the departmental and institutional levels	
D. DEPARTMENTAL SUPPORT								
1	**There is a collaborative communication process in place, including disseminating new ideas**		There is no department wide communication strategy for sharing new ideas about V&C	There is an informal communication strategy to discuss new ideas about V&C but includes only a small group of participants with infrequent, irregular meetings	There is an informal communication strategy to discuss new ideas about V&C and includes the majority of department members with frequent, but irregular meetings	There is a formal communication strategy including both face to face meetings and email exchanges to discuss new ideas about V&C, all deparment members are invited and some collaboration is discussed	Components of 3 are present and active collaboration around the V&C takes place	
2	**There is faculty support for the administrative vision within the department**		Department faculty are unaware of the administrative vision	Department faculty are aware of the administrative vision but express hesitancy to adopt the vision for the department (avoid discussing at meetings; express worry or negativity; express confusion on how to adopt this vision)	Department faculty are aware of the administrative vision and express verbal willingness/support for the vision, but no formal action is taken	Components of 2 are present and action is taken but no reporting or formal mechanism is developed for implementing the vision long-term	Components of 3 are present and formal reporting is conducted on current actions, and a plan is written on how to achieve the vision over long-term	

The PULSE Vision & Change *Snapshot* Rubric version 2.0

The PULSE Vision & Change Snapshot Rubric is designed as a tool for faculty and administrators to gain a quick overview of the alignment of their life science program with some of the major elements of the recommendations of the *Vision and Change* (V&C) report (2011). The PULSE Vision & Change Snapshot Rubric includes components of the five separate rubrics that make up the complete PULSE Vision & Change rubrics: 1) Curriculum Alignment, 2) Assessment, 3) Faculty Practice/Faculty Support, 4) Infrastructure, and 5) Climate for Change. The complete set of rubrics is designed as a diagnostic tool to be used in a self-study to evaluate the extent of implementation of the recommendations of the Vision and Change (V&C) report (2011) in life science programs and majors. They were developed based on the features expected in a department that had fully implemented all of the V&C recommendations. The rubrics help departments and programs highlight the areas where they stand out and areas where they have made less progress. The complete set of rubrics is part of a Recognition process that acknowledges departments and programs that have made progress in implementation of V&C recommendations. More information is available here: http://www.pulsecommunity.org/page/recognition.

This short Snapshot Rubric is intended to be used for several purposes: a) as an entry point or gateway to the complete set of five rubrics, b) as a brief overview for conference and workshop participants, and c) as a standardized instrument to collect data across the PULSE regional meetings in various geographical locations. Most of the criteria come directly from the complete set of rubrics, but in a few instances multiple full rubric criteria have been collapsed into one for the sake of brevity.

Departments can compare their scores to those of other institutions (of similar or different types) and use the data to develop plans for program changes to better align with national priorities for STEM education. Data collected using the rubrics are extremely valuable in understanding the landscape of teaching and learning that exists and how that landscape is changing over time. Thus, we are very interested in collecting data from departments who fill out the Snapshot rubric. We have established an online rubric data entry portal. Please consider depositing your department's information in the Snapshot rubric data entry portal (http://www.pulsecommunity.org/page/recognition)

The use of the term 'faculty' throughout the rubric is meant as a generic term for the range of possible titles for all those who are instructors in any course that is part of the program being evaluated. The use of 'term' is intended to encompass whatever unit is relevant for individual institutions, such as semester or quarter.

The specific instructions in the next section go through each criterion of the Snapshot rubric, providing details to clarify meaning and scoring. They are best used concurrently with the rubric. Links are provided for navigation between the instructions and rubric sections. These links *(go to rubric, go to instructions)* can be found next to each section heading and will take the PDF-user back and forth within this document.

Instructions for the PULSE Vision & Change *Snapshot* Rubric v2.0

The core concepts and competencies described in *Vision and Change* reflect the combined thinking of thousands of scientists over the past decade or more. For specific descriptions of the core concepts and core competencies, please refer to Chapter 2 of the 2011 *Vision and Change* report, particularly pages 12-16. Because of this strong consensus among life scientists, we are using the language in the *Vision and Change* 2011 report as the basis for this evaluation.

A. INTEGRATION OF CORE CONCEPTS INTO CURRICULUM *(go to rubric)*

A1 – Integration of core concepts into the curriculum
The five V&C core concepts are evolution; structure and function; information flow, exchange and storage; pathways and transformations of energy and matter; and systems. For details of specific concepts to be covered, refer to the BioCore Guide (Brownell *et al.* 2014) available here
http://www.lifescied.org/content/suppl/2014/05/16/13.2.200.DC1/Supplemental_Material_2.pdf.

B. INTEGRATION OF CORE COMPETENCIES INTO CURRICULUM *(go to rubric)*

B2 – Integration of core competencies into the curriculum
This criterion measures the number of competencies that students are exposed to in detail in the process of completing a major/program.

B3 – Extent of core competency integration into the curriculum
This criterion measures whether students have multiple detailed exposures to the competencies in the process of completing a major/program.

The following are brief descriptions of the six core competencies described in the *Vision and Change* report (2011). More detail can be found in Chapter 2 of the report.

Process of science
This competency concerns development of student competency regarding the application of the process of science. Achieving this competency requires providing students with opportunities to practice formulating hypotheses, testing them experimentally or observationally, and analyzing the results.

Quantitative reasoning
This competency concerns development of student competency regarding the use quantitative reasoning. For quantitative reasoning resources visit this URL: http://www.nimbios.org/resources/. For a recent paper on integrating quantitative reasoning into an introductory biology course see: Hester *et al.* CBE—Life Sciences Education Vol. 13, 54–64, Spring 2014.

Modeling and simulation
This competency concerns development of student competency regarding use of modeling and simulation. Because biological systems are complex, changing, and interacting, the opportunity to learn about and practice modeling and simulating those systems can provide students with insight into the important means of clarifying these dynamic interactions. Examples of modeling/simulation software include SimBio (http://simbio.com), STELLA (http://www.iseesystems.com), and NetLogo (http://ccl.northwestern.edu/netlogo/).

Interdisciplinary nature of science
This competency concerns development of student competency to tap into the interdisciplinary nature of science. Sub-disciplines of biology are often reaching to other disciplines to learn techniques and approaches that can shed light on biological phenomena. Achieving this outcome can be supported by a climate that values interdisciplinary thinking and provides opportunities for students to develop some fluency in other disciplines through associated coursework, course activities (e.g. by integrating interdisciplinary case studies), course-based interaction with students and experts in other disciplines or in collaborations outside the classroom setting. Another way to foster interdisciplinary competence is through courses that are co-taught by a life scientist and an instructor from another discipline, e.g. mathematics, computer science, chemistry, anthropology, physics, and engineering.

Communication and collaboration
This competency concerns development of communication skills. It is important for students to learn to communicate effectively in typical written and oral scientific formats, and this communication is necessary for effective collaboration with colleagues within and outside the student's discipline.

Understanding of the relationship between science and society
This competency concerns development of student competency to understand the relationship between science and society. Scientific study and research are conducted within social structures and, consequently, scientists need to understand how those social structures work and how to participate in society such that both science and society benefit. Another aspect is instilling in students the idea that science can be used to help solve major societal problems, for example human disease and environmental degradation. For this connection to be made, students need to understand not only the science, but also the complexity of the social problems that are addressed.

C. COURSE LEVEL ASSESSMENT *(go to rubric)*

The PULSE website (http://www.pulsecommunity.org/page/assessment) contains links to many assessment tools listed below.

C4 – Linkage of summative assessments to learning outcomes
This criterion requires careful articulation of course-level learning outcomes and intentional selection or development of assessments to measure student achievement of the outcomes. The PULSE community website link provided at the beginning of this section includes a wide variety of assessments that can be used in specific life science courses or could provide ideas for development of local course-specific instruments. A major goal of any assessment program should be to gain information that can be used to improve student learning in the future; a second important goal would be demonstration of achievement for specific students. For a score of three or four, it is essential that assessments be valid and carefully mapped to the outcomes (rather than generically appropriate for the course such as a standardized test used across many sections which provides broad information about student knowledge, but is difficult to use for specific course improvements).

C5 – Evaluation of time devoted to student-centered activities in courses
This criterion is focused on time spent in student-centered activities. Ideally, both student and peer-observers should have a chance to evaluate this factor. For student assessment, course evaluations might include questions about specific active learning techniques. A variety of instruments for peer observation to assess this criterion are currently in use, for example, The Classroom Observation Protocol for Undergraduate STEM (COPUS) (http://www.lifescied.org/content/12/4/618.full) and the Reformed Teaching Observation Protocol

(RTOP) (http://serc.carleton.edu/NAGTWorkshops/certop/reformed_teaching.html). 'Term' refers to either semester or quarter, as appropriate for the specific institution.

D. PROGRAM LEVEL ASSESSMENT *(go to rubric)*

D6 – Assessment of the six V&C competencies at the program level
This criterion seeks to specifically address the integration of the *Vision and Change* core competencies into a major or program. Ideally, this would best be evaluated with some sort of single "exit exam" based on *Vision and Change* core competencies. However, such an instrument does not currently exist. Some standardized tests, for example the Educational Testing Service's Major Field Test in Biology, assess a subset of *Vision and Change* core competencies. A second option is to use some sort of portfolio evaluation during the students' final year in the program. The use of ePortfolios for this purpose is gaining traction. See http://net.educause.edu/ir/library/pdf/eli3001.pdf for an overview or browse the *International Journal of ePortfolio* (http://www.theijep.com).

D7 – Use of data on program effectiveness
This criterion speaks to what extent the analyzed program effectiveness data is used to strengthen the program and encourages departments to consider collecting and analyzing program effectiveness data to inform program revision. Direct measures of student learning include comprehensive exam/concept inventory scores for graduating students, portfolios, capstone projects, or oral examinations. Indirect measures include course grades, measures of the number of students that progress to graduate school or employment, and comparison of enrollment numbers. A fairly comprehensive list of direct and indirect measures of student learning can be found at: http://www.csuohio.edu/offices/assessment/exmeasures.html.

E. PEDAGOGY AND STUDENT HIGHER LEVEL LEARNING *(go to rubric)*

E8 – Opportunities for inquiry, ambiguity, analysis, and interpretation in coursework
This criterion is focused on the degree to which scientific inquiry is incorporated into courses, whether or not the course includes a formal laboratory component. In other words, to what degree do students have the opportunity to do what scientists do, namely design experiments, formulate hypotheses, and evaluate data? One key component is to expose students to data sets where the interpretation of the data affects the conclusions drawn, exposing them to the ambiguity inherent in scientific investigation. Another key point here is that class time should not be dedicated solely to presentation of facts, but instead should expose students to the process of science, namely hypothesis generation, hypothesis testing, data analysis, and drawing scientific conclusions.

E9 – Student metacognitive development
This criterion addresses the degree to which instructors encourage students to reflect on their own learning or metacognition. Metacognition is defined as the process of setting challenging goals, identifying strategies to meet them, and monitoring progress toward them. For scores of 3 or 4, instructors integrate the practice of effective learning strategies supported by cognitive research and reflection on learning into course assignments and assessments. An example of a metacognitive assignment is asking students to review returned exams and correct their answers. The use of the term 'faculty' is meant as a generic term for the range of possible titles for instructors in any course that is part of the program being evaluated.

E10 – Student higher-order cognitive processes
This criterion is focused on the type of thinking required of students and whether assignments and assessments are designed to give students adequate practice, particularly in developing higher order cognitive skills. The

lowest order cognitive processes focus on *knowledge and comprehension* and require students to memorize, name, label, define, arrange, classify, identify, restate, and select. The process of application requires students to apply, demonstrate, interpret, use, or solve. Higher order cognitive processes include *analysis* (requiring students to analyze, categorize, compare, contrast, differentiate, and test), *synthesis* (requiring students to compose, create, design, organize, and propose), and *evaluation* (requiring students to appraise, assess, defend, evaluate, judge, and predict).

E11 – Alignment of pedagogical approaches with evidence-based practices
This criterion is focused on the use of evidence-based practices in student learning. Two factors are being assessed here: first, the degree to which student-focused approaches are used in the classroom and second, the number of faculty members who are using these approaches. There is a wide range of student-focused approaches including use of student response devices (clickers) and group activities often associated with case-based or problem-based learning. To support claims of extensive use of evidence-based pedagogy, scoring of active learning using COPUS (http://www.lifescied.org/content/12/4/618.full) or other tools would be required to justify a score of 4. Counts of courses using evidence-based, active engagement strategies and inquiry vs. traditional lecture format would be appropriate evidence for scores of 2-3.

E12 – Awareness of national efforts in undergraduate STEM education reform
This criterion addresses the degree to which faculty members are aware of national reports on biology and STEM education like the 2011 AAAS *Vision and Change* report, the 2015 *Vision and Change: Chronicling the Change* report or the 2012 *Engage to Excel* PCAST (Presidential Council of Advisors on Science and Technology) report. Are faculty members aware of the HHMI Summer Institutes? Are faculty members interested and aware that these reports support making their classrooms student-focused and inquiry-based? Are faculty aware and willing to consider that there is strong evidence from educational and cognitive science studies that student-centered teaching strategies are more effective for learning than lecture-based teaching?

F.   LEARNING ACTIVITIES BEYOND THE CLASSROOM *(go to rubric)*

F13 – Intramural and/or extramural mentored research: student participation
This criterion pertains to the number of students that carry out mentored student research. Research here is intended to refer to research that takes place outside of formally scheduled laboratory classes or capstone courses. Examples include research with a faculty member from the institution, research with a faculty member from another institution, summer mentored research opportunities, or research opportunities with local biotech/pharmaceutical/environmental companies. To be considered, the student must participate in research for a minimum of one term or one summer. The student time commitment minimum is 10 hours per week for academic year work.

F14 – Supplemental student engagement opportunities
This criterion addresses whether the institution offers supplemental student engagement opportunities. These opportunities include 1) availability of tutoring (Are tutors available? Are there sufficient tutors to satisfy student demand? Are the tutors free for students or at least free for students on financial aid?), 2) Peer mentoring (Are there formal peer mentoring programs set up by the institution? These could be one-on-one programs or programs where a peer mentor works with multiple students.), 3) Supplemental instruction (This would include formal peer-led study groups that are associated with the class or extra class sections for students that need help mastering fundamentals.), 4) Academic advisors (Are academic advisors available for students? Are there sufficient academic advisors to meet student demand? Do students meet with academic advisors frequently enough to establish an effective and beneficial relationship?), 5) Learning communities (Are there opportunities for life science students to live/socialize together?), 6) Interest-based or career oriented clubs

(clubs organized around pre-health, pre-vet, biotech, pharma, life science majors. The effectiveness of these clubs can be assessed by the number of students that are actively involved or by the number of events they sponsor per year), and 7) Practicums and internships (this partially overlaps with F13 above, but here the practicums or internships are not strictly research-based, e.g. they could be more job or profession specific such as shadowing opportunities, co-ops, service learning, etc.). 'Institutionalized,' for a score of 4, refers to permanent funding for these opportunities.

G. INFRASTRUCTURE AND CLIMATE *(go to rubric)*

G15 – Flexibility of teaching spaces
This criterion is related to the quality of the actual teaching space. When estimating the percentage of classrooms, for the denominator, use the classrooms that are generally assigned to the department for teaching; for the numerator, use the subset that is flexible and reconfigurable. A flexible and reconfigurable classroom contains furniture that can be easily (and quickly) rearranged to accommodate student groups of different sizes. Single level classrooms are generally more conducive to active learning than tiered rooms. An example of a classroom that is not flexible and reconfigurable would be a lecture hall with multiple tiers and fixed seating.

G16 – Mechanisms for collaborative communication on significant educational challenges
This criterion addresses the degree to which stakeholders (faculty, staff, administrators, etc.) across the institution effectively communicate about nationally-recognized and institution-specific challenges and issues in undergraduate STEM education. Such discussions might include how to address recommendations from national reports and studies, educational best practices, data on student outcomes, and measures of student success. Institution-specific data and issues might include DFW rates, retention, persistence, success of students from non-traditional and underrepresented backgrounds, and outcomes such as graduation rates, types of employment, rate of entry into additional educational programs, etc. For scores of 3 and 4, formal mechanisms such as committees or working groups are likely to exist that actively engage key stakeholders across the institution around these issues. To achieve a score of 4, discussions that identify significant disparities or issues must lead to changes in programs to address those issues.

G17 – Teaching in formal evaluation of faculty
Formal evaluation includes regular/annual review, promotion, and tenure of faculty. Use of 'faculty' is meant as a generic term for the range of possible titles for instructors in any course that is part of the program being evaluated. Although all institutions value teaching, different institutions weigh components of faculty effort (e.g. teaching, research, service) differently. Student course evaluations are variable at different institutions. At a minimum, course evaluations ask for student perceptions about the quality of the class and the quality of the faculty. At the high end, course evaluations might ask about the teaching approaches utilized and student perception of learning gains. Peer evaluations are reviews by other faculty of teaching effectiveness and can include information about the strategies utilized and the level of student engagement. Scholarly teaching (scientific teaching) is the practice of evaluating whether students achieve learning goals and reflecting on teaching practices to continuously improve student outcomes.

PULSE Snapshot Rubric v2.0

Institution Type: _____ Institution Name: _____Program/Department/Major: _____Your Name (Optional) _____

	Criteria	0 (Baseline)	1 (Beginning)	2 (Developing)	3 (Accomplished)	4 (Exemplar)
A. INTEGRATION OF CORE CONCEPTS INTO CURRICULUM *(go to instructions)*						
1	**Integration of core concepts into the curriculum**	None of the core concepts are covered multiple times in the curriculum	One or two of the core concepts are covered multiple times in the curriculum	Three of the five core concepts are covered multiple times in the curriculum	Four of the five concepts are covered multiple times in the curriculum	All five core concepts are covered multiple times in the curriculum
Core concepts are: Evolution; Structure/function; Information flow/exchange/storage; Pathways and transformations of energy and matter; Systems						
B. INTEGRATION OF CORE COMPETENCIES INTO CURRICULUM *(go to instructions)*						
2	**Integration of core competencies into the curriculum**	Students are not exposed to any of the core competencies in significant detail	Students are exposed to one or two of the core competencies in significant detail	Students are exposed to three of the six core competencies in significant detail	Students are exposed to four or five of the six core competencies in significant detail	Students are exposed to all six of the core competencies in significant detail
3	**Extent of core competency integration into the curriculum**	None of the core competencies are covered multiple times in the curriculum	One or two of the core competencies are covered multiple times in the curriculum	Three of the six core competencies are covered multiple times in the curriculum	Four or five of the six core competencies are covered multiple times in the curriculum	All six of the core competencies are covered multiple times in the curriculum
Core competencies are: Process of science; Quantitative reasoning; Modeling and simulation; Interdisciplinary nature of science; Communication and collaboration; Understanding of the relationship between science and society						
C. COURSE LEVEL ASSESSMENT *(go to instructions)*						
4	**Linkage of summative assessments to learning outcomes**	Summative assessments are not linked to learning outcomes	Some courses have summative assessments that measure learning outcome achievement	Many courses have summative assessments that measure learning outcome achievement	The majority of courses have summative assessments that measure learning outcome achievement	The majority of courses have summative assessments that measure learning outcome achievement as part of a coherent, evidence-based assessment plan
5	**Evaluation of time devoted to student-centered activities in courses**	Time spent in student-centered activities is not measured	Time spent in student-centered activities is informally estimated at the end of term	Time spent in student-centered activities is documented by approximation after the fact in formal course evaluation at the end of term	Time spent in student-centered activities is informally tracked throughout the term and reported in formal course evaluations at the end of term	Time spent in student-centered activities is formally documented at points throughout the term and reported in formal course evaluations at the end of term
D. PROGRAM LEVEL ASSESSMENT *(go to instructions)*						
6	**Assessment of the six V&C competencies at the program level**	Competencies not assessed at the program level	Development of at least one of the competencies assessed at the program level	Development of 2-3 competencies assessed at the program level	Development of 4-5 competencies assessed at the program level	Development of all 6 V&C competencies assessed at the program level
7	**Use of data on program effectiveness**	Program is not revised in response to data on program effectiveness	Program revision occurs in response to indirect data on program effectiveness only	Program revision occurs in response to indirect data and one source of direct data on program effectiveness	Program revision occurs in response to indirect data and 2-3 sources of direct data on program effectiveness	Program revision occurs in response to indirect data and 4 or more sources of direct data on program effectiveness

PULSE Snapshot Rubric v2.0

8	**Opportunities for inquiry, ambiguity, analysis, and interpretation in coursework**	Most courses, regardless of lab component, do not provide opportunities for inquiry, ambiguity, analysis, and interpretation; students have little exposure	25% or less of courses, regardless of lab component, provide opportunities for inquiry, ambiguity, analysis, and interpretation; a subset of students are exposed	~26-50% of courses, regardless of lab component, provide opportunities for inquiry, ambiguity, analysis, and interpretation; many student are exposed	Greater than 50% of courses, regardless of lab component, have opportunities for inquiry, ambiguity, analysis, and interpretation; most students are exposed	Opportunities for inquiry, ambiguity, analysis, and interpretation are the norm in all courses, regardless of lab component; nearly all students are exposed; many get multiple opportunities to practice
9	**Student metacognitive development**	Faculty do not guide students to reflect on and understand how to use learning strategies that are supported by cognitive research	Less than 25% of faculty guide students to reflect on and understand how to use learning strategies that are supported by cognitive research	25-50% of faculty guide students to reflect on and understand how to use learning strategies that are supported by cognitive research	51- 75% of faculty guide students to reflect on and understand how to use learning strategies that are supported by cognitive research	Greater than 75% of faculty routinely and intentionally guide students to reflect on and understand how to use learning strategies that are supported by cognitive research
10	**Student higher-order cognitive processes**	Exams and assignments across the curriculum are focused on the lowest-level cognitive processes (memorization/recall)	Exams and assignments across the curriculum are typically at lower cognitive levels, but may include understanding and application in addition to recall	Less than 25% of courses routinely challenge students to use higher-order cognitive processes (e.g., synthesize, evaluate, create) on exams and assignments	25-50% of courses routinely require students to use higher-order cognitive processes, but such practice is not yet ubiquitous across the curriculum	Work at higher cognitive levels is the norm across the curriculum, and instructors are adept at developing assignments and exams for practice at each level
11	**Alignment of pedagogical approaches with evidence-based practices**	Lecturing without student engagement is the dominant practice in all courses	Evidence-based pedagogies are used by one or few instructors	A core group of faculty are shifting department attitudes and practices toward more widespread use of evidence-based pedagogies, although courses in which students experience uninterrupted lecture are common	Nearly all faculty are learning about and experimenting with evidence-based pedagogical practices, although courses in which students experience uninterrupted lecture are a standard part of the curriculum	Majority of faculty routinely use evidence-based practices, so that students rarely sit passively listening to lectures for an entire class session
12	**Awareness of national efforts in undergraduate STEM education reform**	Faculty are isolated from the national dialogue	Pockets of awareness of the need for reform and national efforts exist	Greater than 25% of the faculty are aware of the need for reform and national efforts	Greater than 50% of the faculty are aware of the need for reform and national efforts	Greater than 75% of faculty are aware of the need for reform and national efforts in undergraduate STEM education

13	**Intramural and/or extramural mentored research: student participation**	No students participate in mentored research	Less than 15% of students graduate with one or more summer/term of mentored research	15-30% of students graduate with one or more summer/ term of mentored research	31-60% of students graduate with one or more summer/ term of mentored research	Greater than 60% of students graduate with one or more summer/term of mentored research
14	**Supplemental student engagement opportunities**	Supplemental engagement opportunities are absent	One or two supplemental engagement opportunities are offered, but available to few students	More than two supplemental engagement opportunities are available, but only to a small subset (~25%) of students	Supplemental engagement opportunities are diverse, but capacity is limited (~50% of students)	Supplemental engagement opportunities are diverse, widely available to all students, and institutionalized

G.	INFRASTRUCTURE AND CLIMATE *(go to instructions)*					
15	**Flexibility of teaching spaces**	All assigned classrooms are lecture style with fixed seating	Less than 10% of assigned classrooms are flexible and reconfigurable to encourage student interaction	10-50% of assigned classrooms are flexible and reconfigurable to encourage student interaction	51-75% of classrooms are flexible and reconfigurable to encourage student interaction; different types of classrooms are available for diverse teaching styles	More than 75% of classrooms are flexible and reconfigurable to encourage student interaction; different types of classrooms are available for diverse teaching styles
16	**Mechanisms for collaborative communication on significant educational challenges**	There is little discussion of educational challenges that impact student success (e.g. retention, persistence, success of underrepresented students)	There is informal discussion of educational challenges that impact student success, but discussions include only a limited group of stakeholders with infrequent, irregular meetings	Informal discussion of educational challenges that impact student success includes the majority of college stakeholders, but discussions are irregular	Formal communication mechanism such as a working group or committee exists for discussion of educational challenges that impact student success. The committee includes the majority of college stakeholders	Formal communication mechanism (working group or committee) exists for discussion of educational challenges that impact student success. The committee includes the majority of college stakeholders, who collaborate actively to make changes that have impact
17	**Teaching in formal evaluation of faculty**	Teaching is not considered in the evaluation of faculty	Teaching is considered a minor component in the evaluation of faculty, but is based solely on student course evaluations that assess only the student perception of the quality of the class and faculty	Teaching is considered an important component of the overall formal evaluation. Evaluation is based on both student course evaluations and peer evaluations	Teaching is considered a major component of the overall formal evaluation. Evaluation is based on student course evaluations, peer evaluations, and recognition of the importance of scholarly teaching	Teaching is considered a major component of the overall formal evaluation. Evaluation is based on student course evaluations, peer evaluations, assessment of learning gains, and recognition of the importance of scholarly teaching