APPENDIX I

Chemistry Program Review Outcomes Chemistry Sample

VI. Learning Outcomes Assessment Data:

Exhibit VI.A: Review all learning outcomes assessment work plans developed in discipline or program.

Outcome 1	Measureable Criteria	Measurement Tool	Courses	Time Frame
Demonstrate knowledge of **chemical structure** to predict and explain the physical properties of chemical materials.	An average score of at least 80% or better on homework and 70% or better on homework and exam questions relating to **chemical structure**.	Homework, Exams	CHEM 110 CHEM 221 CHEM 222 CHEM 223	Data collection begins: 2015-2016 Analysis begins: 2016-2017

2015-2016 Results:

CHEM 221 – FL15	Average		Average		Average
HW Chp. 1	N/A	**HW Chp. 7**	87%	**Exam 1**	79%
HW Chp. 2	96%	**HW Chp. 8**	93%	**Exam 2**	70%
HW Chp. 3	N/A	**HW Chp. 9**	86%	**Final Exam**	
HW Chp. 4	N/A	**HW Chp. 10**	90%		

CHEM 110 – FL15	Average		Average		Average
HW Chp. 2	91%	**HW Chp. 8**	79%	**Exam 1**	80%
HW Chp. 3	97%	**HW Chp. 17**		**Exam 2**	57% (n=1)
HW Chp. 5	84%	**HW Chp. 19**		**Final Exam**	
HW Chp. 6	N/A	**HW Chp. 21**			

Analysis:

CHEM 221
Homework: 90%, Exams: 75%

CHEM 110
Homework: 88%, Exams: 69%

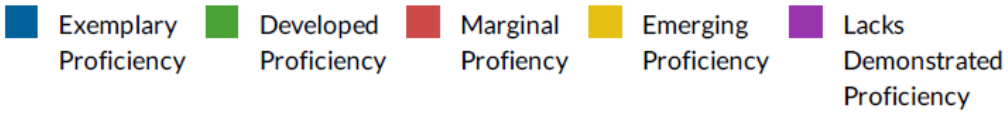
Plan:
I will continue to examine my teaching methodologies and exam and homework questions to improve these numbers.

Further, although students have met my standards, it is difficult to know whether they have met national standards. To compare student achievement in my courses to student achievement in General Chemistry courses nation-wide, I plan to administer an American Chemical Society approved exam for general chemistry at the conclusion of CHEM 223.

Outcome 1	Measureable Criteria	Measurement Tool	Courses	Time Frame
Demonstrate knowledge of **chemical structure** to predict and explain the physical properties of chemical materials.	**CHEM 110/GS 105/CHEM 221:** at least 75% achieve "emerging proficiency" **CHEM 222:** at least 75% achieve "marginal proficiency" **CHEM 223:** at least 75% achieve "developed proficiency" **CHEM 245/246/247:** at least 75% achieve "exemplary proficiency"	Homework, Exams, Chemical structure rubric, ACS Exam	GS 105 CHEM 110 CHEM 221 CHEM 222 CHEM 223 CHEM 245 CHEM 246 CHEM 247	Data collection begins: WT17 Analysis begins: SP17

2016-2017 winter Results:

WINTER 2017



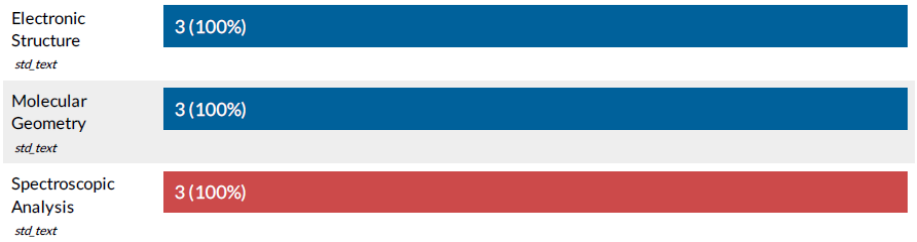
Rubric View: Chemical Structure Rubric **CHEM 110**

	Exemplary Proficiency (4 pts)	Developed Proficiency (3 pts)	Marginal Profiency (2 pts)	Emerging Proficiency (1 pts)	Lacks Demonstrated Proficiency (0 pts)	*Mean*	*Mode*	*Stdev*
Electronic Structure	0	0	21	0	2	1.826	2.000	0.564
Molecular Geometry	0	0	0	20	3	0.870	1.000	0.337
Spectroscopic Analysis	0	0	0	0	0	0.000	NA	0.000

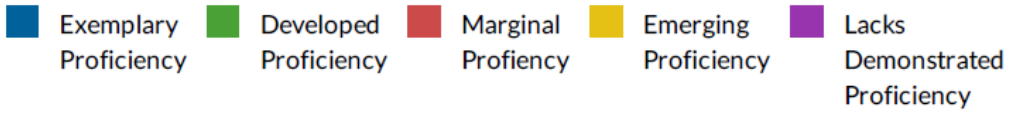
CHEM 110 GOAL:	WT17 RESULTS:
At least 75% of students achieve at least "emerging proficiency"	**88.5%** of students achieved at least "emerging proficiency"

Rubric View: Chemical Structure Rubric **CHEM 246**

	Exemplary Proficiency (4 pts)	Developed Proficiency (3 pts)	Marginal Profiency (2 pts)	Emerging Proficiency (1 pts)	Lacks Demonstrated Proficiency (0 pts)	*Mean*	*Mode*	*Stdev*
Electronic Structure	3	0	0	0	0	4.000	4.000	0.000
Molecular Geometry	3	0	0	0	0	4.000	4.000	0.000
Spectroscopic Analysis	0	0	3	0	0	2.000	2.000	0.000



CHEM 246 GOAL:	**WT17 RESULTS:**
At least 75% of students achieve at least "exemplary proficiency"	**100%** of students achieved at least "exemplary proficiency"



Rubric View: Chemical Structure Rubric **GS 105**

	Exemplary Proficiency (4 pts)	Developed Proficiency (3 pts)	Marginal Profiency (2 pts)	Emerging Proficiency (1 pts)	Lacks Demonstrated Proficiency (0 pts)	*Mean*	*Mode*	*Stdev*
Electronic Structure	0	17	2	0	0	2.895	3.000	0.307
Molecular Geometry	0	0	17	2	0	1.895	2.000	0.307
Spectroscopic Analysis	0	0	0	0	0	0.000	NA	0.000

GS 105 GOAL:	**WT17 RESULTS:**
At least 75% of students achieve at least "emerging proficiency"	**100%** of students achieved at least "emerging proficiency"

2016-2017 Winter Results

RESULTS: 100% of students in both CHEM 246 and GS 105 achieved the desired level of performance in the categories of chemical structure. 88.5% of students in CHEM 110 achieved the desired level of performance with regards to chemical structure.

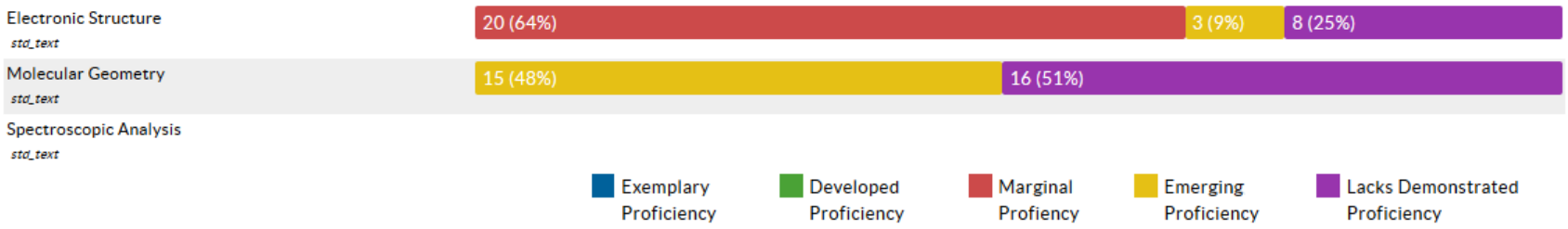
ANALYSIS: Although a majority of students scored at the desired level of performance in this exercise, I believe that there is more work to be done. I do believe that these data reflect the true abilities of my students in this category, as I have been sufficiently impressed with their understanding of chemical structure. However, the data seem to indicate that nearly all of the students in the course are achieving at the same level; I do not necessarily believe this result. I think that the problem lies within the chemical structure rubric; if it were designed more carefully, it could be used to investigate these differences in abilities between students in the same course, even if they are achieving at the desired performance level.

PLAN: This initial assessment is promising, but I believe that students can perform even better in this area. I will take another look at the "chemical structure rubric" to see if I can change the wording of each category to better match student performance and to better tease out small differences in performance among students in the same course. Another possibility is to increase the measurable criteria for this outcome; rather than expecting 75% to perform better than "marginal proficiency", perhaps I should expect 75% to perform at or better than "developed proficiency".

SPRING 2017
CHEM 110

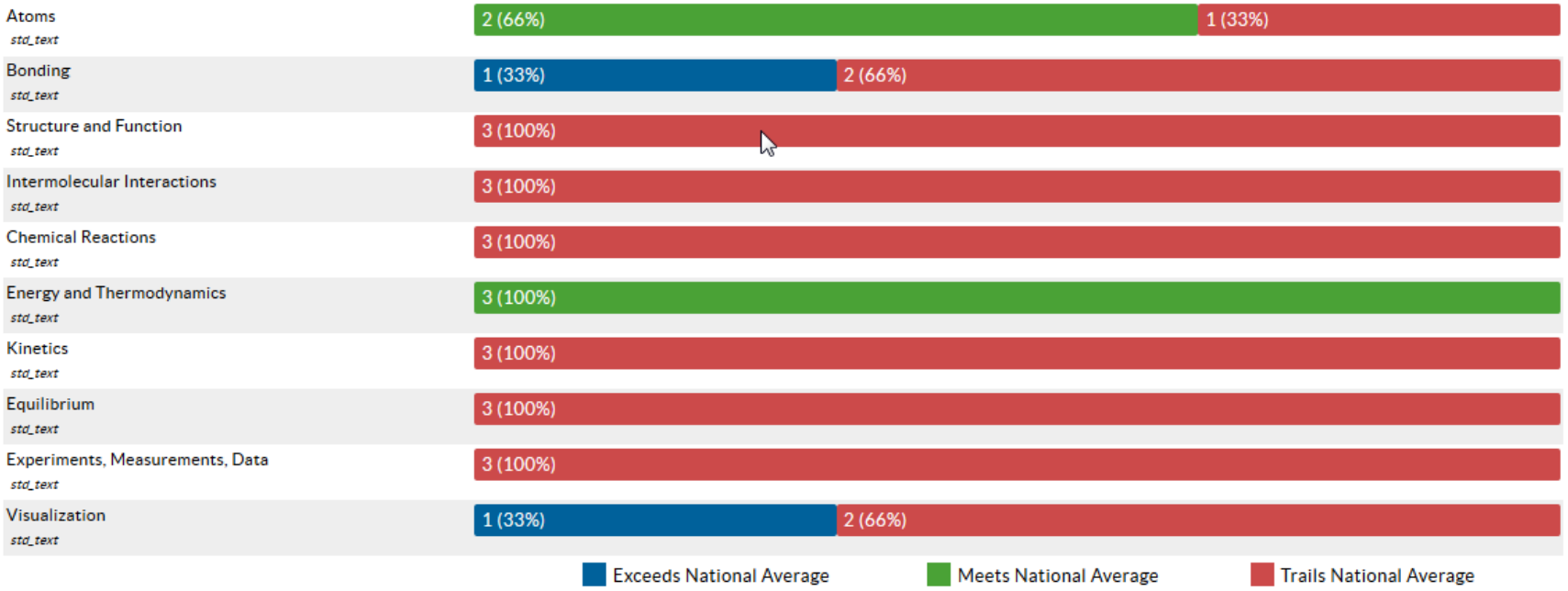
Rubric View: Chemical Structure Rubric

	Exemplary Proficiency (4 pts)	Developed Proficiency (3 pts)	Marginal Profiency (2 pts)	Emerging Proficiency (1 pts)	Lacks Demonstrated Proficiency (0 pts)	*Mean*	*Mode*	*Stdev*
Electronic Structure	0	0	20	3	8	1.387	2.000	0.868
Molecular Geometry	0	0	0	15	16	0.484	0.000	0.500
Spectroscopic Analysis	0	0	0	0	0	0.000	NA	0.000



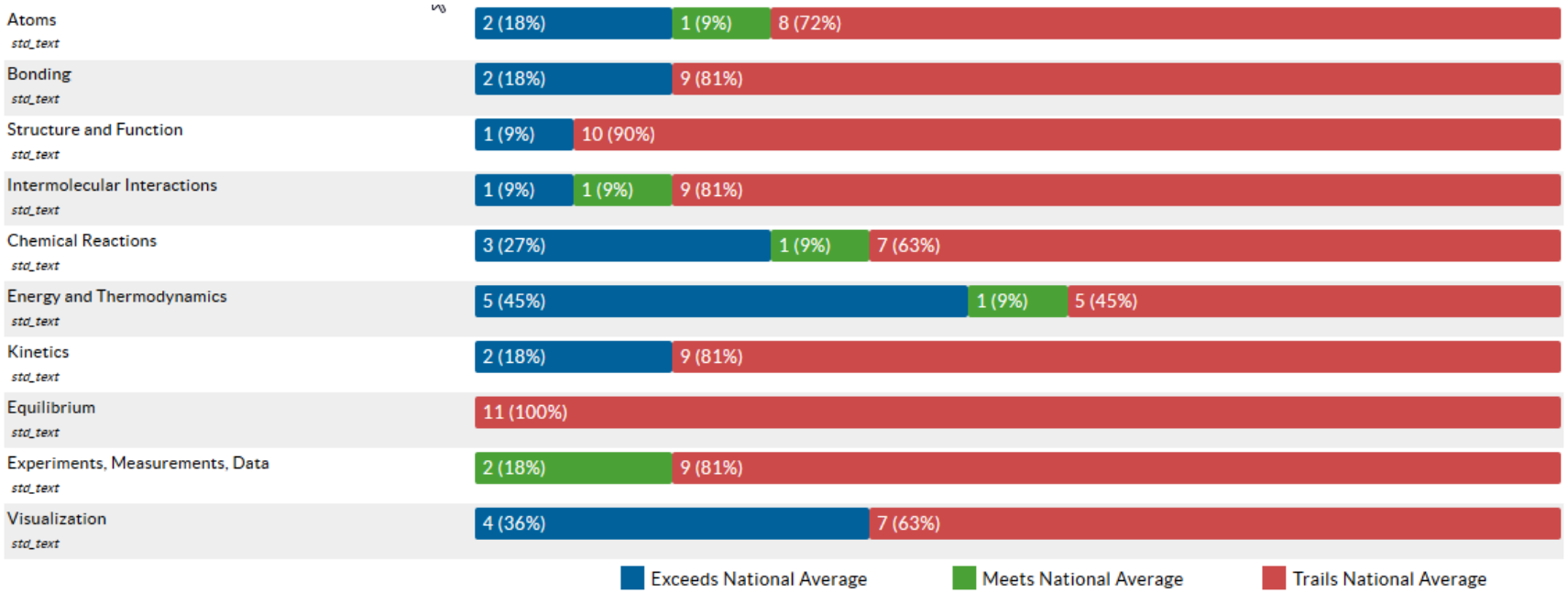
CHEM 110 GOAL:	**SP17 RESULTS:**
At least 75% of students achieve at least "emerging proficiency"	**60.5%** of students achieved at least "emerging proficiency"

CHEM 223-01



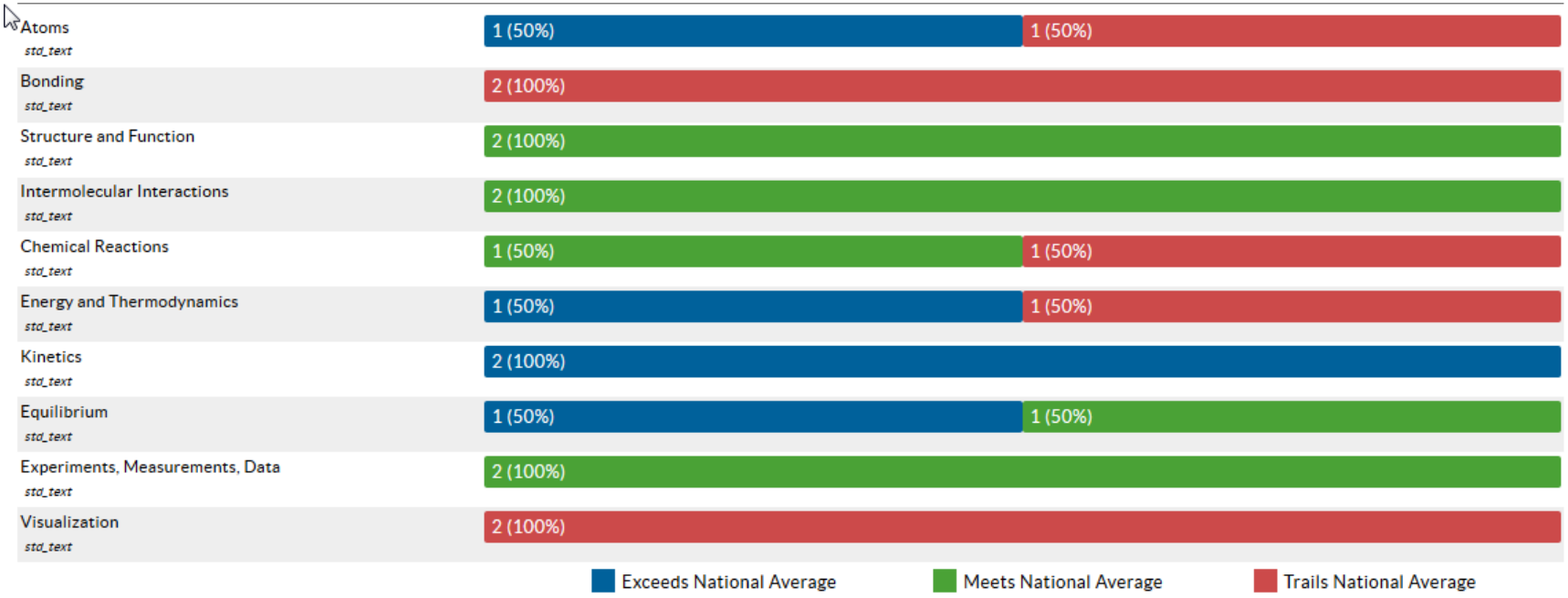
CHEM 223 GOAL:	**SP17 RESULTS:**
At least 75% of students achieve at least "meets national average"	**Many areas met national average, but many areas were trailing national average**

CHEM 223-02



CHEM 223 GOAL:	**SP17 RESULTS:**
At least 75% of students achieve at least "meets national average"	**Many areas met national average, but many areas were trailing national average**

CHEM 247



CHEM 247 GOAL:	SP17 RESULTS:
At least 75% of students achieve at least "meets national average"	**Many areas met national average, but many areas were trailing national average**

2016-2017 Spring Results

RESULTS: Although many areas were at or above the national average, there were many areas that were below the national average.

ANALYSIS: Many of the chemistry concepts were covered well, but students were not adequately prepared for the math portion of the course and many of the areas where students fell below the national average were “math-heavy” concepts.

PLAN: I am working with the math department to coordinate certain topics from the chemistry sequence so that they can be reinforced within math courses. We are working to coordinate the schedule of certain topics across chemistry, math, and physics, so that concepts can be introduced in one course, and reinforced in the other courses, both in terms of when the topics are introduced, as well as the specific content of assignments.

Outcome 2	Measureable Criteria	Measurement Tool	Courses	Time Frame
Demonstrate knowledge of **chemical reactivity** to predict and explain the outcomes of reactions.	An average score of at least 80% or better on homework and 70% or better on homework and exam questions relating to **chemical reactivity**.	Homework, Exams, ACS Exam	CHEM 110 CHEM 221 CHEM 222 CHEM 223	Data collection begins: 2015-2016 Analysis begins: 2016-2017

Results:

CHEM 221 – FL15	Average		Average		Average
HW Chp. 1	N/A	**HW Chp. 7**	N/A	**Exam 1**	86%
HW Chp. 2	N/A	**HW Chp. 8**	N/A	**Exam 2**	86%
HW Chp. 3		**HW Chp. 9**	N/A	**Final Exam**	
HW Chp. 4		**HW Chp. 10**	N/A		

CHEM 110 – FL15	Average		Average		Average
HW Chp. 2	N/A	**HW Chp. 8**	79%	**Exam 1**	82%
HW Chp. 3	N/A	**HW Chp. 17**		**Exam 2**	83%
HW Chp. 5	N/A	**HW Chp. 19**		**Final Exam**	
HW Chp. 6	88%	**HW Chp. 21**			

Analysis:

CHEM 221
Homework: N/A, Exams: 86%

CHEM 110
Homework: 84%, Exams: 82%

Plan:

I will continue to examine my teaching methodologies and exam and homework questions to improve these numbers.

Further, although students have met my standards, it is difficult to know whether they have met national standards. To compare student achievement in my courses to student achievement in General Chemistry courses nation-wide, I plan to administer an American Chemical Society approved exam for general chemistry at the conclusion of CHEM 223.

Outcome 3	Measureable Criteria	Measurement Tool	Courses	Time Frame
Demonstrate knowledge of **chemical quantitation** to predict and explain chemical phenomena.	An average score of at least 80% or better on homework and 70% or better on exam questions relating to **chemical quantitation**.	Homework, Exams, ACS Exam	CHEM 110 CHEM 221 CHEM 222 CHEM 223	Data collection begins: 2015-2016 Analysis begins: 2016-2017

Results:

CHEM 221 – FL15	Average		Average		Average
HW Chp. 1	97%	**HW Chp. 7**	N/A	**Exam 1**	N/A
HW Chp. 2	N/A	**HW Chp. 8**	N/A	**Exam 2**	N/A
HW Chp. 3	N/A	**HW Chp. 9**	N/A	**Final Exam**	
HW Chp. 4	N/A	**HW Chp. 10**	N/A		

CHEM 110 – FL15	Average		Average		Average
HW Chp. 2	93%	**HW Chp. 8**	79%	**Exam 1**	N/A
HW Chp. 3	N/A	**HW Chp. 17**		**Exam 2**	68%
HW Chp. 5	N/A	**HW Chp. 19**		**Final Exam**	
HW Chp. 6	88%	**HW Chp. 21**			

Analysis:

CHEM 221
Homework: 97%, Exams: N/A

CHEM 110
Homework: 87%, Exams: 68%

Plan:

I will continue to examine my teaching methodologies and exam and homework questions to improve these numbers.

Further, although students have met my standards, it is difficult to know whether they have met national standards. To compare student achievement in my courses to student achievement in General Chemistry courses nation-wide, I plan to administer an American Chemical Society approved exam for general chemistry at the conclusion of CHEM 223.

Outcome 4	Measureable Criteria	Measurement Tool	Courses	Time Frame
Critical Thinking: Collect and analyze data using classical methods and modern instrumentation and evaluate experimental results using the principles of the scientific method.	An average score of at least a 70% or better on correct identification of unknowns.	Identification of Unknowns, VALUE Rubric: Critical Thinking	CHEM 221 CHEM 222 CHEM 223	Data collection begins: 2015-2016 Analysis begins: 2016-2017

2015-2016 Results:

Results:

	Average
CHEM 221 (FL15)	(no data)
CHEM 222 (WT16)	72%
CHEM 223 (SP16)	63%

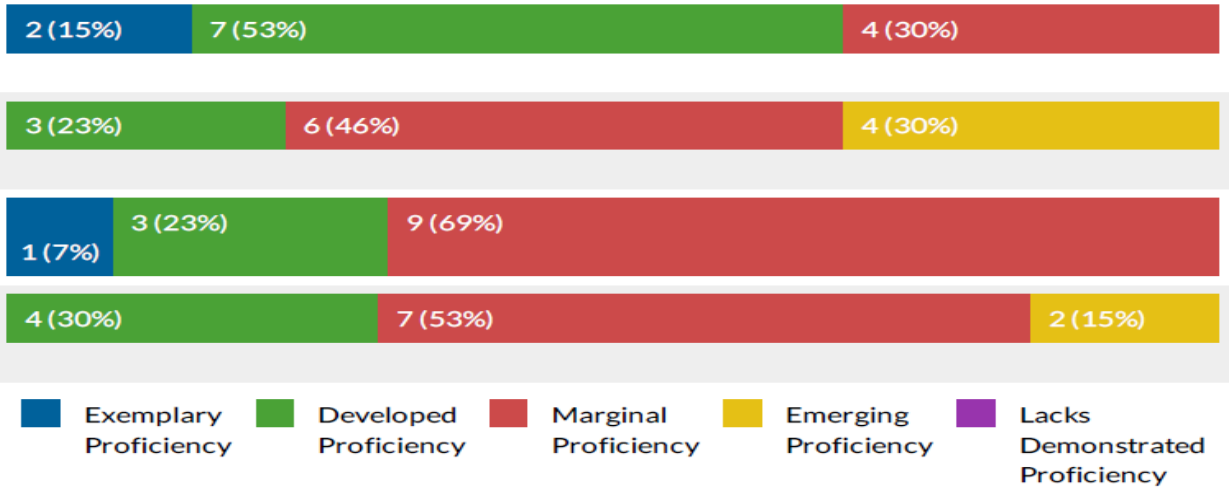
Analysis:
Average = 67.5%

Plan:
These numbers indicate that students are having a hard time "connecting the dots," as it were, with regard to analysis of experimental data. To improve these numbers, I will continue to work with my students to help them identify the important aspects of a situation and to avoid fallacies of logic and critical thinking.

2016-2017 Results:

Rubric View: Chemistry Lab Report Rubric **CHEM 222**

	Exemplary Proficiency (4 pts)	Developed Proficiency (3 pts)	Marginal Proficiency (2 pts)	Emerging Proficiency (1 pts)	Lacks Demonstrated Proficiency (0 pts)	*Mean*	*Mode*	*Stdev*
Introduction / Background Info	2	7	4	0	0	2.846	3.000	0.662
Literature Evidence	0	3	6	4	0	1.923	2.000	0.730
Data and Results	1	3	9	0	0	2.385	2.000	0.625
Discussion and Conclusion	0	4	7	2	0	2.154	2.000	0.662



% scoring at least "marginal proficiency"
Data and Results 100%
Discussion and Conclusion 83%

2016-2017 Winter Results

RESULTS: 100% and 83% of students in CHEM 222 scored at least a "marginal proficiency" in the categories of "data and results" and "discussion and conclusion", respectively, of the chemistry laboratory report rubric.

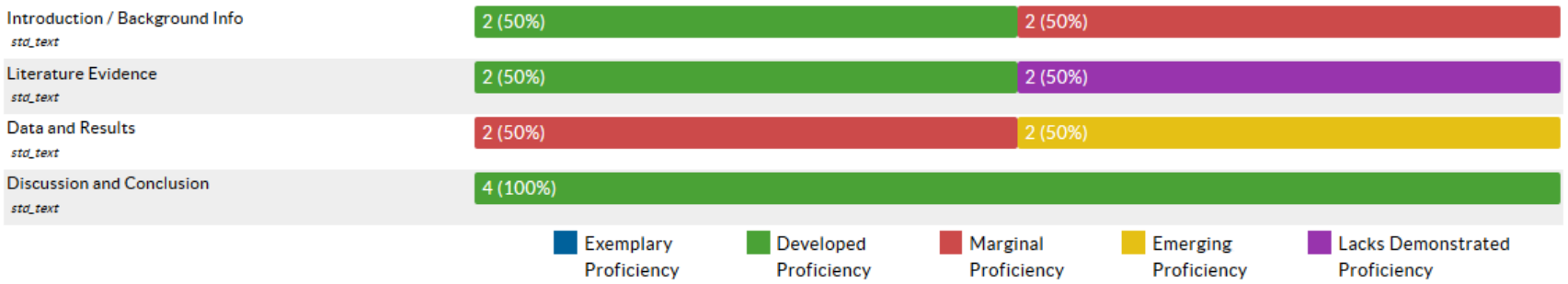
ANALYSIS: Although a majority of students scored above marginal proficiency in this exercise, I believe that there is more work to be done. My feeling is that students are not performing at the necessary level with regard to interpreting and analyzing experimental results; the fact that my data do not support this feeling suggests that I scored students too high when assessing their work or that I should expect more than "marginal proficiency" from these students.

PLAN: Although this initial assessment is promising, I believe that students can perform even better in this area. I will take another look at the "lab report rubric" to see if I can change the wording of each category to better match student performance. Another possibility is to increase the measurable criteria for this outcome; rather than expecting 75% to perform better than "marginal proficiency", perhaps I should expect 75% to perform at or better than "developed proficiency".

CHEM 223-01

Rubric View: Chemistry Lab Report Rubric

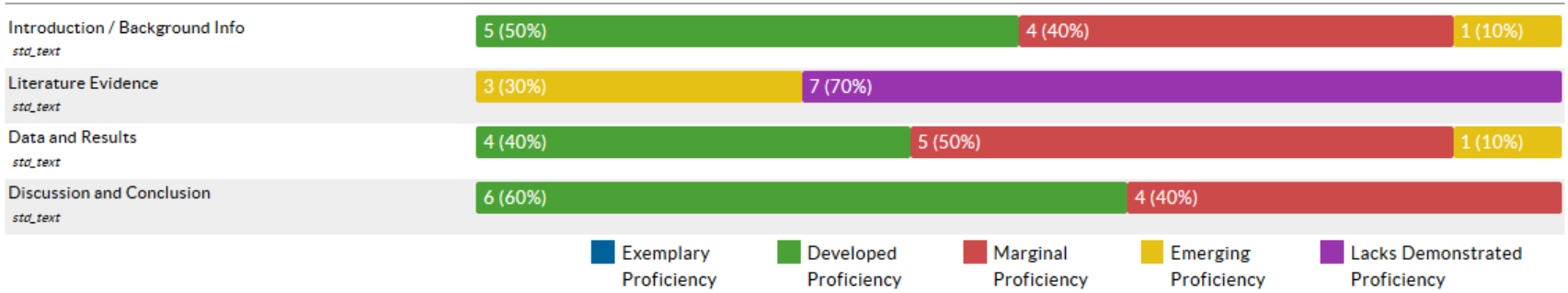
	Exemplary Proficiency (4 pts)	Developed Proficiency (3 pts)	Marginal Proficiency (2 pts)	Emerging Proficiency (1 pts)	Lacks Demonstrated Proficiency (0 pts)	*Mean*	*Mode*	*Stdev*
Introduction / Background Info	0	2	2	0	0	2.500	2.000	0.500
Literature Evidence	0	2	0	0	2	1.500	0.000	1.500
Data and Results	0	0	2	2	0	1.500	1.000	0.500
Discussion and Conclusion	0	4	0	0	0	3.000	3.000	0.000



CHEM 223-02

Rubric View: Chemistry Lab Report Rubric

	Exemplary Proficiency (4 pts)	Developed Proficiency (3 pts)	Marginal Proficiency (2 pts)	Emerging Proficiency (1 pts)	Lacks Demonstrated Proficiency (0 pts)	*Mean*	*Mode*	*Stdev*
Introduction / Background Info	0	5	4	1	0	2.400	3.000	0.663
Literature Evidence	0	0	0	3	7	0.300	0.000	0.458
Data and Results	0	4	5	1	0	2.300	2.000	0.640
Discussion and Conclusion	0	6	4	0	0	2.600	3.000	0.490



2016-2017 Spring Results

RESULTS: In CHEM 223-01, 50% of students received a score of "marginal proficiency" in data and results and 100% of students received a score of "developed proficiency" in discussion and conclusions. In CHEM 223-02, 90% of students received a score of "marginal proficiency" or better in data and results and 100% of students scored "marginal proficiency" or better in discussion and conclusions.

ANALYSIS: Students performed well on this learning outcome. This term in CHEM 223, we had a 10-week project where students were able to make a hypothesis, collect data, interpret the results, and write a lab report. Students were able to successfully collect and interpret their data. I think that there are several reasons that this term went better than last term: 1) the students had more practice from CHEM 221/222; 2) the entire lab sequence was based on one project, so students could keep adding to their knowledge week after week instead of starting a new experiment every week; 3) students were told to work independently, so they weren't as able to rely on their partner's work.

PLAN: Moving forward, I would like to create more term-long laboratory projects. It seems that having an open-inquiry, on-going lab project was conducive to critical thinking. I will design term-long lab projects for CHEM 221, 222, 245, 246, and 247.

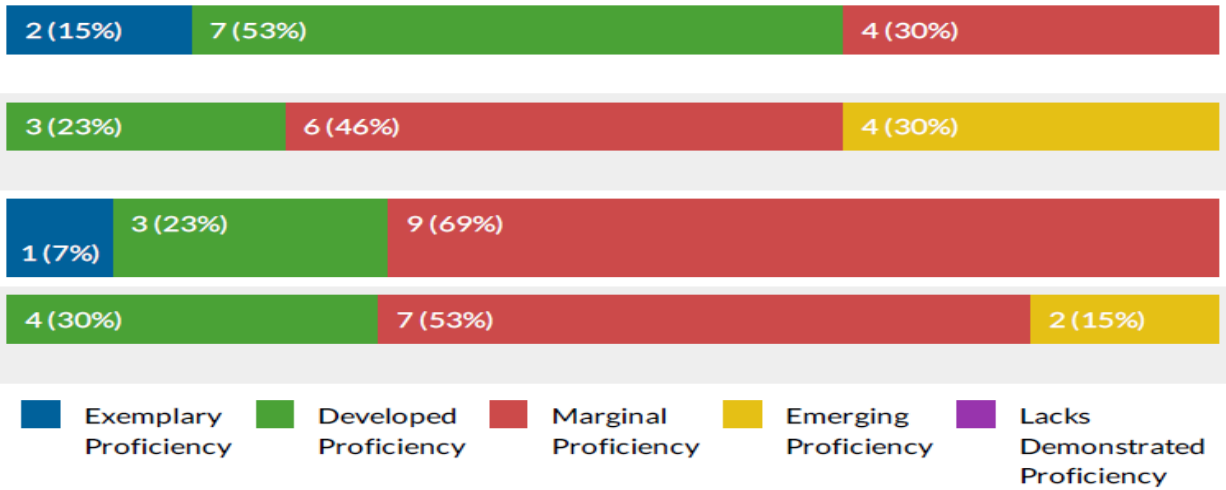
Outcome 5	Measureable Criteria	Measurement Tool	Courses	Time Frame
Information Literacy: Locate, summarize, and critique scientific articles, as well as synthesize scientific information from various sources to communicate the results of their own experiments.	At least 75% of students will achieve at least "Marginal Proficiency" on the Chemistry Lab Report Rubric in the categories of "Introduction/Background Info" and "Literature Evidence"	Lab report, VALUE Rubric: Information Literacy	CHEM 222	Data collection begins: WT17 Analysis begins: SP17

2016-2017 Results:

Rubric View: Chemistry Lab Repor **CHEM 222**

	Exemplary Proficiency (4 pts)	Developed Proficiency (3 pts)	Marginal Proficiency (2 pts)	Emerging Proficiency (1 pts)	Lacks Demonstrated Proficiency (0 pts)	*Mean*	*Mode*	*Stdev*
Introduction / Background Info	2	7	4	0	0	2.846	3.000	0.662
Literature Evidence	0	3	6	4	0	1.923	2.000	0.730
Data and Results	1	3	9	0	0	2.385	2.000	0.625
Discussion and Conclusion	0	4	7	2	0	2.154	2.000	0.662

% scoring at least "marginal proficiency"	
Intro/Background Info	100%
Literature Evidence	69%



2016-2017 Winter Results

RESULTS: 100% and 69% of students in CHEM 222 scored at least a "marginal proficiency" in the categories of "intro/background information" and "literature evidence", respectively, of the chemistry laboratory report rubric.

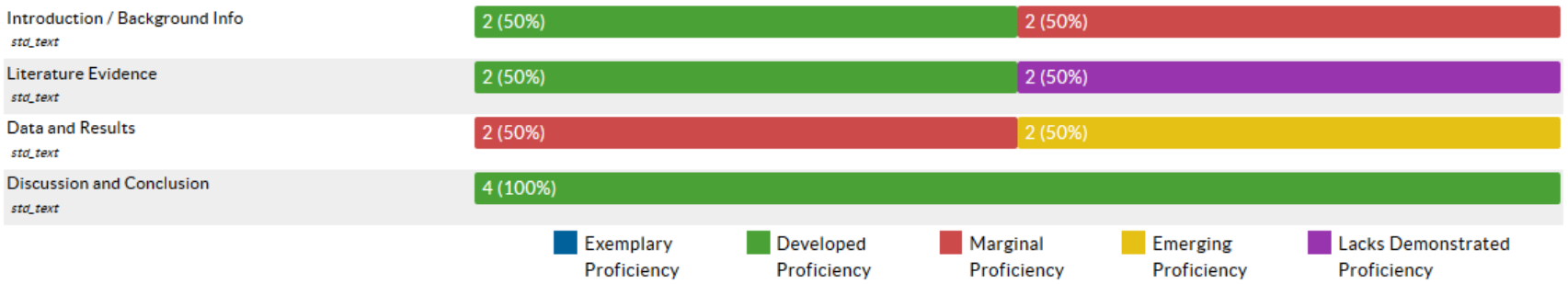
ANALYSIS: Since 100% of students were able to score at least "marginal proficiency" in the area of "introduction/background information", perhaps I should increase the expected performance level. It seems that 68% of students were able to score at least "developed proficiency" in this area. I will look into changing the measurable criteria for this outcome. However, only 69% of students were able to score at least "marginal proficiency" in the area of "literature evidence". This suggests that students are having a difficult time either finding or properly utilizing peer-reviewed articles from the scientific literature when writing their lab reports. This is an essential component of a modern STEM education, so it is imperative that more emphasis is placed on this skill to increase the number of students performing at least at the "marginal proficiency" level. I will reach out to the librarian on campus to suggest the possibility of using a laboratory period to explore the library databases and locate and evaluate peer-reviewed articles.

PLAN: Although this initial assessment is promising, I believe that students can perform even better in this area. I will take another look at the "lab report rubric" to see if I can change the wording of each category to better match student performance. If it turns out that the rubric is capable of capturing the different levels of achievement as currently formatted, then another possibility is to increase the expected measurable criteria for each student outcome; perhaps I am underestimating what I can expect students at this level to accomplish. Therefore, another possibility is to increase the measurable criteria for this outcome; rather than expecting 75% to perform better than "marginal proficiency", perhaps I should expect 75% to perform at or better than "developed proficiency".

CHEM 223-01

Rubric View: Chemistry Lab Report Rubric

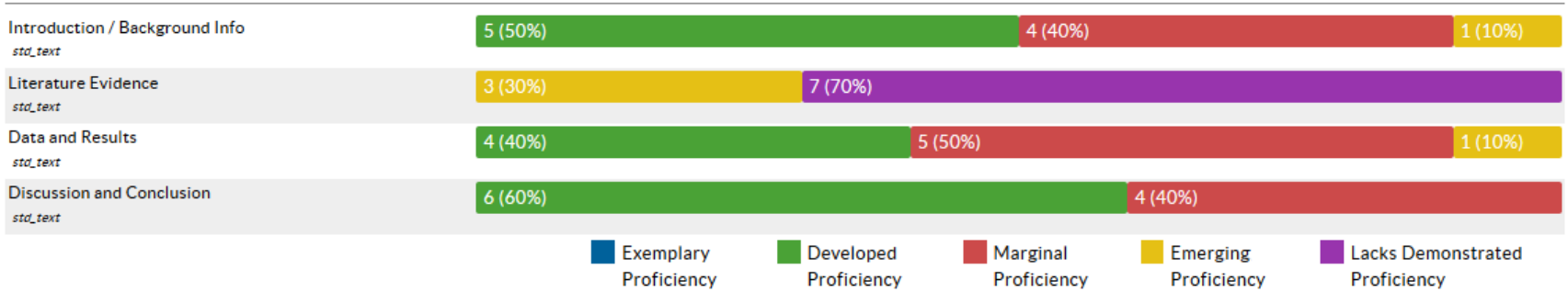
	Exemplary Proficiency (4 pts)	Developed Proficiency (3 pts)	Marginal Proficiency (2 pts)	Emerging Proficiency (1 pts)	Lacks Demonstrated Proficiency (0 pts)	*Mean*	*Mode*	*Stdev*
Introduction / Background Info	0	2	2	0	0	2.500	2.000	0.500
Literature Evidence	0	2	0	0	2	1.500	0.000	1.500
Data and Results	0	0	2	2	0	1.500	1.000	0.500
Discussion and Conclusion	0	4	0	0	0	3.000	3.000	0.000



CHEM 223-02

Rubric View: Chemistry Lab Report Rubric

	Exemplary Proficiency (4 pts)	Developed Proficiency (3 pts)	Marginal Proficiency (2 pts)	Emerging Proficiency (1 pts)	Lacks Demonstrated Proficiency (0 pts)	*Mean*	*Mode*	*Stdev*
Introduction / Background Info	0	5	4	1	0	2.400	3.000	0.663
Literature Evidence	0	0	0	3	7	0.300	0.000	0.458
Data and Results	0	4	5	1	0	2.300	2.000	0.640
Discussion and Conclusion	0	6	4	0	0	2.600	3.000	0.490



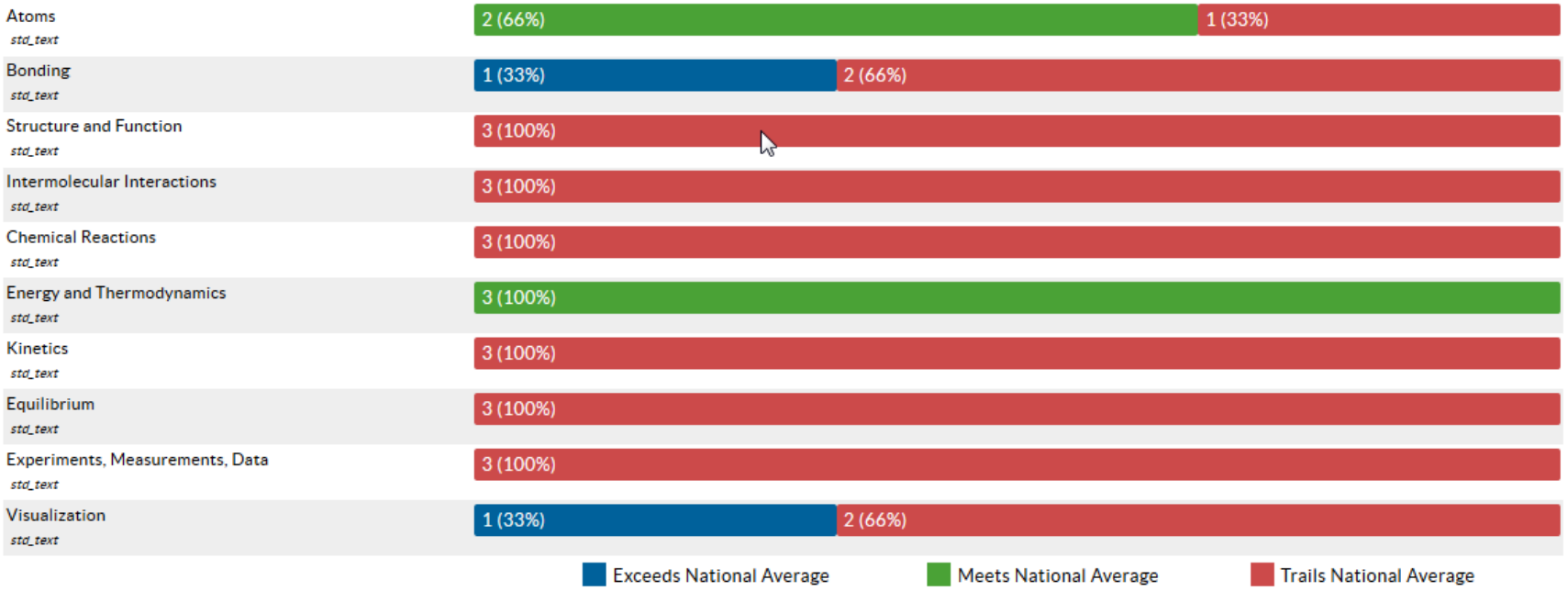
2016-2017 Spring Results

RESULTS: In CHEM 223-01, 100% of students scored at least marginal proficiency in introduction/background info and 50% of students scored developed proficiency in literature evidence. In CHEM 223-02, 90% of students scored at least marginal proficiency in introduction/background info and 0% of students scored marginal proficiency in literature evidence.

ANALYSIS: Students seem to have understood the components of a good introduction for a lab report. They were consistently able to explain what the experiment was about and why it was important. However, they were not very good at supporting this information using some outside source (literature evidence).

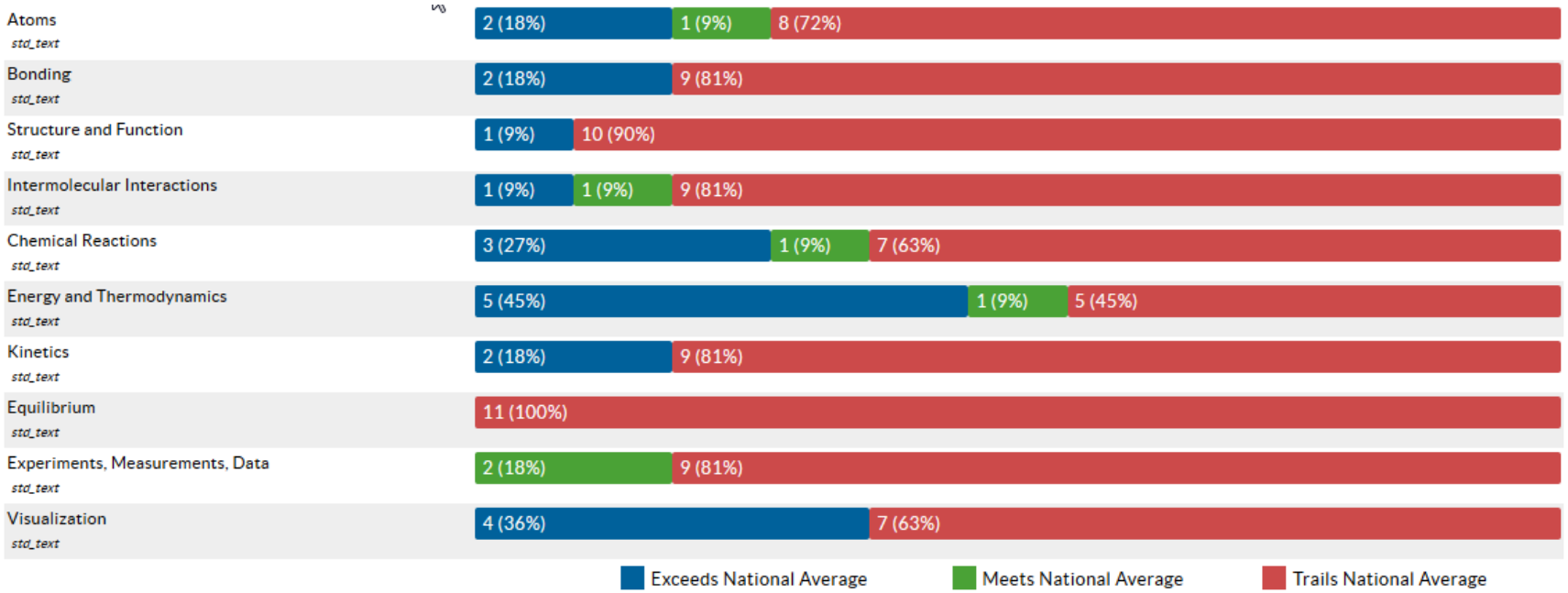
PLAN: I will work with the library to develop a module for my students to learn about computer databases and how to find relevant information for papers and lab reports. I will also introduce students to more peer-reviewed articles so they can start to see how literature evidence is used in professional papers.

CHEM 223-01



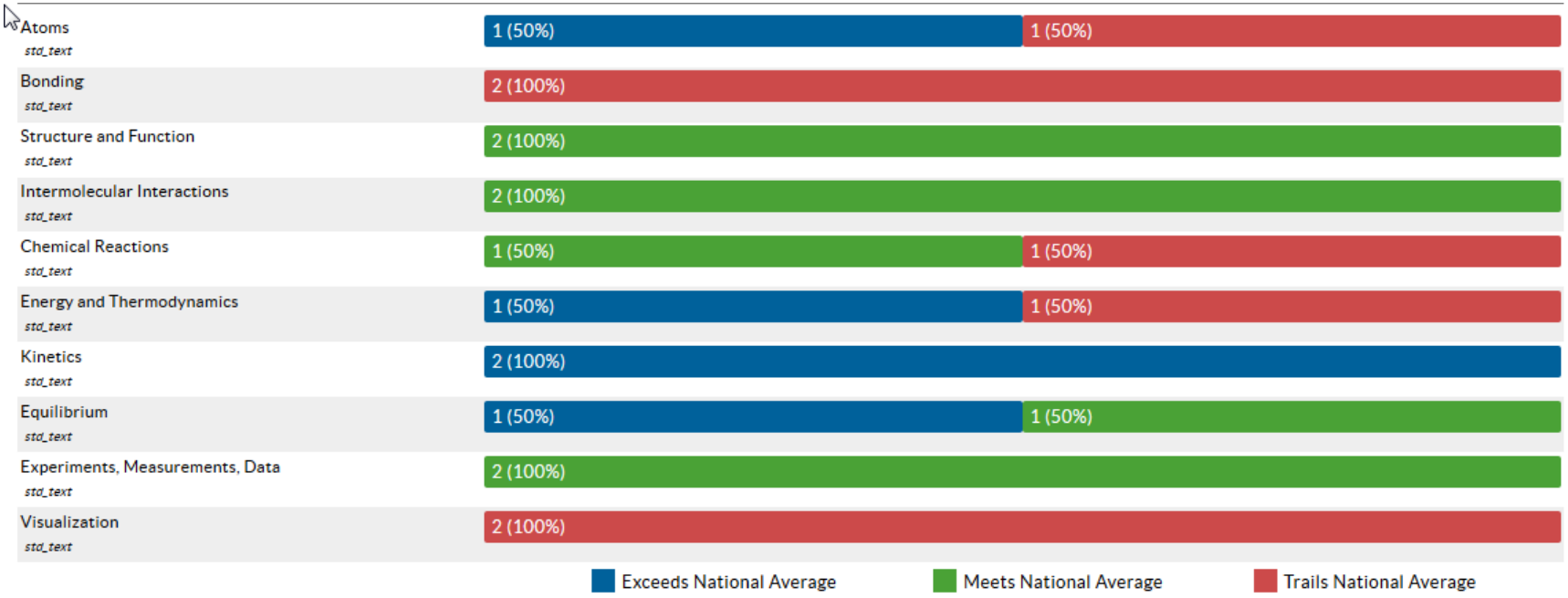
CHEM 223 GOAL:	**SP17 RESULTS:**
At least 75% of students achieve at least "meets national average"	**Many areas met national average, but many areas were trailing national average**

CHEM 223-02



CHEM 223 GOAL:	**SP17 RESULTS:**
At least 75% of students achieve at least "meets national average"	**Many areas met national average, but many areas were trailing national average**

CHEM 247



CHEM 247 GOAL:	SP17 RESULTS:
At least 75% of students achieve at least "meets national average"	**Many areas met national average, but many areas were trailing national average**

Outcome 6	Measureable Criteria	Measurement Tool	Courses	Time Frame
Global Learning: Demonstrate personal and social responsibility, environmental stewardship, and global self-awareness.	Student responses on survey	VALUE Rubric: Global Learning	GS 105 CHEM 221 CHEM 222 CHEM 223	Data collection begins: FL17 Analysis begins: FL17

Results: N/A

Analysis: N/A

Plan: To assess this learning outcome, a research report assignment has been created that asks students to choose one of the social/global issues that we discussed during class, like pollution or climate change, and to investigate further. This report will be assessed by using the VALUE rubric for Global learning. The plan is to assess this learning outcome for the first time at the end of CHEM 223 and CHEM 247 in Spring 2018.