2023-2024 Annual Assessment Report for the Masters of Science in Environmental Management

Name of program: Masters of Science in Environmental Management (MSEM)
Type of program: Graduate Program
College of Arts and Sciences

Authors: Amalia Kokkinaki, April Randle, Paul Nesbit, Allison Luengen
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Table of Contents

I. Summary

This report outlines the assessment activities related to the MSEM program for Academic Year 2023-2024. As per our planned assessment schedule, the MSEM program assessed PLO2 using work products from the capstone course of the program ENVM698 Master's Project with a sample size of 16 students.

PLO2 "Utilize both theory and applied knowledge to evaluate and recommend management strategies for environmental issues." is a cumulative learning outcome that naturally lends itself to assessment during the student's master's project. Master's project is a semester-long course in which students review the scientific literature to produce an original synthesis of their research topic in order to make environmental management recommendations. In addition, all MSEM students complete Research methods, allowing us to maximize the number of data points we can obtain for evaluating the PLO.

In addition to assessing student performance relative to PLO2 this year, there are five goals that we are trying to achieve. The goals are listed below, followed by the proposed action that will be taken as a result of this assessment.

1. We wanted to **evaluate the wording of the PLO** itself to make data collection consistent and reproducible. We are looking for the assessment process to allow us to improve the interpretability of the PLO and to **develop key performance indicators (KPIs).**

   We have developed KPIs as well as a proposal for a reworded PLO and corresponding reworded KPIs. We identified difficulties in interpretation for the first KPI and changed the wording to address it.

2. In addition to developing KPIs, we want to ensure that faculty and students have **clarity on the interpretation of the KPIs**. This is necessary given the range of subjects that students research in their Master's Project. To provide an example, "using theory and applied knowledge" can be interpreted in different ways in the fields of water management, ecosystem management, health and hazards, climate policy evaluation and geospatial analysis.

   We have created draft guidance to clearly interpret the KPIs to assist faculty providing assessment data in their work, and to standardize the meaning of the words "theory" and "applied knowledge" across all concentrations in the degree for the benefit of both students and faculty.

3. In collecting the data, we also found that the **CLO to PLO mapping** is not explicit in the Master's project syllabi (both reports and presentations). We think that students may not demonstrate their mastery of PLO2 because they are not asked to do that by the Master's project rubrics, and this problem is more evident in the oral presentations due to the short duration of the presentation. With this assessment, we wanted to explore modifying rubrics for Master's Project to develop expectations that align with PLOs.

   We propose modification of the existing rubric for the Master's project report and presentation to explicitly ask that the students provide evidence based on the theoretical underpinnings and applied knowledge in their field. This aligns the CLO and PLO mapping explicitly, and also allows collection of data directly from the graded reports on Canvas, without asking the instructor to do additional work. When the instructor grades reports on Canvas, the rating for the corresponding criterion on the rubric can be collected and used in the PLO assessment.

4. In developing the KPIs, we want to assess whether the final report or the MP presentation is the **best work product to use** for this assessment. We have utilized both in the past and each has its significant shortcomings. We are looking forward to the recommendations on this topic, given our findings.

   We have concluded that both work products are useful and needed in the assessment of this PLO. We have put in place processes to make the collection of data automatic for the Master's project report (see previous point), and we will implement a protocol on collecting enough data from independent faculty reviewers for Master's project presentations to generate information that we can statistically analyze to evaluate temporal or inter-section variability in the future.

5. We recently made the course "ENVM690 Research Methods" a required course for the program. ENVM690 prepares our students for research in their Master's project, providing skills on technical writing, and for accessing, reviewing, and synthesizing primary literature. We will use the findings and feedback on this assessment to evaluate potential changes in the syllabi, rubrics, and other **curricular improvements in**

Research Methods, with the aim of helping students gain the necessary skills required to evaluate and recommend management strategies.

Two of the assessment committee members will be teaching Research Methods this coming Spring and will work on this task. We look forward to feedback on this report that will guide our efforts.

Our Methodology section outlines the data collection and analyses completed to achieve the above stated objectives. We want to note that the goal this year is in both assessing whether students meet the PLO as it stands now, as well as KPI development and PLO improvement. We have plans for complementary data collection with our Fall 2024 graduating class to assess inter-rater variability, and we plan to continue assessment of PLOs through our Master's project class to develop a longitudinal dataset.

Closing the loop: We plan to use information and feedback collected this year to finalize the wording of PLO2, the corresponding KPIs, to develop formal guidance for assessing PLO2 and to align course assessment with the program objectives.. We will be fully implementing these changes in next year's assessment cycle. Assessing PLO2 again will allow us to formally evaluate the impact of recent changes such as adding research methods and providing guidance to faculty with new processes for data collection.We will be moving the assessment of PLO4 to the subsequent assessment year. We concluded that moving PLO4 to a later time will not have significant implications for program improvement as students historically have met expectations on PLO4.

II. Logistics

Contact information

Feedback should be sent to the Director of the program, Prof. Amalia Kokkinaki (akokkinaki@usfca.edu) as well as assessment committee members April Randle (amrandle@usfca.edu), Allison Luengen (aluengen@usfca.edu), and Paul Nesbit (pnesbit@usfca.edu) .

Curriculum

Changes to Program Structure

As of academic year 2024-2025, Research Methods has become a required course. As this was a program-level change, the department voted and unanimously approved the change via

anonymous survey on August 30, 2024. Soon thereafter, the Curriculog process was initiated and the change was confirmed by the Dean's office on October 28, 2024.

No other changes to program structure were made.

Program Structure

The MSEM program structure is outlined here. All courses, except Master's Project, are 2 units:

Total units: 30
Required courses (12 units)

First semester:

- ENVM601 Environmental Chemistry
- ENVM602 Ecology
- ENVM603 Quantitative methods

Second semester:

- ENVM690 Research Methods

Last semester

- ENVM698 Master's project

Table 1. Two-year study plan in the MSEM program

Year 1	Course	Units
Fall Semester Year 1		8
A	**Ecology**	2
	Quantitative Methods	2
B	**Environmental Chemistry**	2
	ELECTIVE 1	2
Spring Semester Year 1		8
A	**Research Methods**	2
	ELECTIVE 2	2
B	ELECTIVE 3	2
	ELECTIVE 4	2

Year 2	Course	Units
Fall Semester Year 2		8
A	ELECTIVE 5	2
	ELECTIVE 6	2
B	ELECTIVE 7	2
	ELECTIVE 8	2
Spring Semester Year 2		6
A	ELECTIVE 9	2
semester	**Master's Project**	4
Total Units		**30**

Elective courses (18 units)
Students complete nine elective courses. Elective courses are offered based on faculty availability. A list of all electives can be found on our website. Each semester, electives are offered such that students in all four concentrations have the ability to take at least one elective in their concentration, as faculty availability and cohort size allows.

Concentrations:
Students completing 5 courses within a concentration designation can declare one of the following concentrations:

- Ecosystems
- Water
- Climate and Energy
- Health and Hazards

Curriculum map

There have been no changes to the Curricular Map since the last report. Tables 2 and 3 show the curricular map for PLOs for MSEM Required classes and Elective classes respectively. Master's project, used to assess PLO2, is highlighted in Table 2.

Table 2. Curricular Map for MSEM Program Required classes. I = Introduced, D = Developed, M = Mastered.

Learning outcomes/Course	Demonstrate an interdisciplinary approach in analysis of environmental issues and management strategies	Utilize both theory and applied knowledge to evaluate and recommend management strategies for environmental issues.	Choose and apply appropriate tools, techniques, and (or) technologies to analyze environmental issues.	Skillfully communicate environmental management issues through written reports, oral, and visual presentations.
Environmental Chemistry	N/A	I/D	I	D
Ecology	I	I,D	I	I
Quantitative Methods	N/A	N/A	D	I
Research Methods	M	D	M	D
Master's Project ENVM 698	**M**	**M**	**M**	**M**

Table 3. Curricular Map for MSEM Program Elective courses. I = Introduced, D = Developed, M = Mastered.

Learning outcomes/Course	Demonstrate an interdisciplinary approach in analysis of environmental issues and management strategies	Utilize both theory and applied knowledge to evaluate and recommend management strategies for environmental issues.	Choose and apply appropriate tools, techniques, and (or) technologies to analyze environmental issues.	Skillfully communicate environmental management issues through written reports, oral, and visual presentations.
Aquatic Pollution	M	M	I	M
Climate Change Mit.	D-M	D-M	D	D
Energy Auditing	NA	NA	D	D
Env.Eng. I + II	N/A	N/A	D	D
Env Economics	N/A	I	D	N/A
Environmental Health	M	D	I	D
Environmental Policy	D-M	D	I	D
Env Toxicology	M	D	D	D
Field Survey Management	I	I	D	M
GO Remediation	D	D	D	D
Hazardous Waste Mgt.	I	I	D	I
Marine Resources	D	M	I	M
Natural Resource Ec.	N/A	D	D	N/A
Quantitative Methods	N/A	N/A	D	I
Risk Management	D	D	D	D
Risk Assessment	M	D	D	N/A
Risk Management	M	M	D	M
Stream + Riparian Eco.	D	D	D	D
Sustainability Leadership	D	D	D	D
Sustainability: The Future	D	D	D	D
Sustainable Building	D	D	D	D

Sustainable Design	M	M	D	M
Urban Resilience	D-M	D-M	D	D
Water in Env Management	I	I	D	D
Water Treatment	D	D	D	D
Advanced Data Analysis	M	M	M	M
Wildlife Conservation	I, D	D	D	D

Assessment Schedule

The most recent Academic Program Review for the ENVS Department and the MSEM Program was in spring 2018. Table 2 shows a list of past assessments and plans for future MSEM assessments.

Table 4. Assessment schedule for MSEM Program since 2015-2016 Academic Year.

Academic year	PLOs reviewed
2015-2016	PLO 4: using Master's Project Presentations
2016-2017	PLO 2: using Master's Projects
2017-2018	Skipped this report, with permission, due to lack of a consistent GPD
2018-2019	PLO 3: using 3 introductory required courses
2019-2020	PLO 4: using Master's Project presentations
2020-2021	PLO 3: using Research Methods
2021-2022	Broad Program Assessment
2022-2023	PLO 1: using Master's Project presentation slides
2023-2024	**PLO 2: proposed modifications**
2024-2025	PLO 2: evaluate modifications
2025-2026	PLO 4

III. Mission statement and Program Learning Outcomes

Changes in mission statement since last assessment cycle

Mission Statement

The Environmental Management Program will educate graduate students to provide management solutions to environmental problems using innovative, interdisciplinary approaches in an environmentally just manner.

There have been no changes to the Mission Statement since the last report.

The MSEM Advisory Committee is currently drafting a revised mission statement that they will bring to the department for discussion.

Changes in program learning outcomes since last assessment cycle

There have been no changes to the PLOs since the last report.

Program Learning Outcomes

1. Demonstrate an interdisciplinary approach in analysis of environmental issues and management strategies.
2. Utilize both theory and applied knowledge to evaluate and recommend management strategies for environmental issues.
3. Choose and apply appropriate tools, techniques, and (or) technologies to analyze environmental issues.
4. Skillfully communicate environmental management issues through written reports, oral, and visual presentations.

With the assessment of each PLO going forward, the MSEM Assessment Committee will create key performance indicators for each PLO. In the process of creating KPIs, the committee will draft recommendations for revisions of PLOs to clarify language, improve our

ability to quantitatively and reliably assess each KPI and align the PLOs with the CLOs of the course that the data is collected from. The assessment committee will bring these revisions to the department for discussion and approval of changes. We expect changes to occur after the proposed PLOs/KPIs have been tested at least once.

Program Learning Outcomes assessed in 2022-2023

In the last assessment cycle, we found that a score of 2 (Proficient) is the most common, and a score of 3 (Exceptional) is the next most common. With regards to the efficacy of PLO1 and the assessment product, we found that PLO1 might not be best represented in Master's project presentations and that we should evaluate as a department what would be a better way to demonstrate whether students are meeting this outcome. The information from last year's report will be used when PLO1 is assessed next in our assessment plan.

IV. Methodology for assessment

Overview and Rationale

We understand that the proper methodology for collecting data is to involve a panel of at least three faculty and a calibrated and standardized rubric to assess the PLO. We aim to adhere to these protocols, as we have done in previous assessments. This year, as we worked on PLO2, we decided to engage in exploratory analysis to collect feedback as we implement the newly created KPIs, evaluate potential changes to these KPI's, and then use the information we gather to propose refinements to the PLO in subsequent years.

We also wanted to evaluate whether the project presentations are the most appropriate work product to use to evaluate this particular PLO. While using MP presentations is a cumulative product, the quality of which may correlate with the students' use of theory and applied knowledge to come to their recommendations, these concrete KPIs may not be explicitly incorporated in the short MP presentation. In these presentations, students are typically encouraged to present to a wide audience and avoid technical language that might not be possible to explain in 12 minutes. In addition, PLO2 is more discipline specific and could be subjective, thus clear guidelines are necessary to allow faculty to provide calibrated assessments in future assessment cycles. Data and information collected this year will help improve our process for assessing PLO2 in coming years.

Finally, logistical challenges prevented us from putting in place a thorough data collection plan: this year we had a transition in MSEM director, as well as a change in the assessment committee membership due to sabbaticals. We coordinated as best as we could to ensure enough data collection to help us both assess PLO2 and explore the above questions.

Key Performance Indicators and Rubric for assessment

Key performance indicators were developed by the assessment committee in collaboration with the Program Director in Spring 2024. The indicators were designed to capture the three concepts addressed in PLO2, and the rubric was developed to capture the various levels of mastery that a student demonstrates for each of the KPIs.

Table 5: Key Performance Indicators and rubric for assessing PLO2

Outcomes	Exceeds expectations (3)	Meets expectations (2)	Approaching expectations (1)	Below Expectations (0)
Utilizes theory to evaluate or recommend management strategies	Well documented description of theory, such as highlighting the scientific literature or use of a framework	The theoretical framework for the field is provided, but needs more detail and/or references	The theoretical framework for the field is only briefly discussed	The theoretical framework for the field is provided is not discussed
Utilizes applied knowledge to evaluate or make management recommendations	Applied knowledge is clearly demonstrated in the evaluation or recommendation of an environmental issue and is supported by scientific literature	Applied knowledge is demonstrated, but needs more detail and/or references	Applied knowledge is only briefly discussed	Applied knowledge is not discussed
Recommend management strategies	The recommendation is well supported, such as from analysis of data, synthesis of literature, or comparison of options	The recommendation is solid, but could use just a little more support	The recommendation needs more support	The recommendation is not well supported

Data collection process

Master's project is the capstone project of MSEM. In their master's project, students are expected to identify research questions/hypotheses in an environmental field of their choice, complete a thorough literature review to answer specific research questions and develop environmental management recommendations based on their analyses of the literature. As such, Masters Project should be an ideal curriculum milestone at which PLO2 should be mastered (See curriculum, Table 1). There are two main student products: a) a research report, with an expectation of a minimum of 50 pages and 50 references cited, and b) a 12-min oral presentation, delivered to a general audience. In this final oral presentation, students focus on a subset of their results with an emphasis on management recommendations.

Assessing PLO2 using the full Master's Project report is a reasonable work product as students have the space to demonstrate their use of theories and applied knowledge to answer their questions. However, to identify the level of mastery of PLO2, a reviewer would have to read through a substantial part of the whole report. Masters project instructors read and grade full reports. To leverage the instructor's direct knowledge of the reports' content, this year we asked the instructors of the three sections of MP to provide scores using the rubric for PLO2 based on their knowledge of the full report. We acknowledge that there is a risk of reviewer bias.

To counterbalance potential instructor bias, we also utilized final oral presentations for our data collection. The advantage of using the presentation is that we can collect unbiased, independent data from faculty attending the presentations. The disadvantage is that final oral presentations are brief and, depending on the topic, a student may not explicitly demonstrate the theory and applied knowledge they used in developing their research. In addition, not all faculty are able to attend the presentations, leading to a smaller dataset.

Acknowledging those limitations, we proceeded with collecting data from the four faculty that attended MP presentations; faculty members were not current MP instructors, they represented various disciplines, and provided scores for each KPI using the developed rubric. Since MP presentations happened in three sessions in parallel, not every faculty could provide scores for every student. Five student presentations were attended by more than one faculty; we used these scores to look into inter-reviewer variability. The remaining 11 student presentations were only attended by one faculty member. We used these 11 presentations to evaluate how students met PLO2 based on the presentation. Data from the five student presentations who had two evaluations showed that in two cases there was significant difference in the perception of the KPI. We will use these as case studies to develop guidance on KPI assessment. For three of the five presentations, evaluators were in agreement, and we included these data in the assessment dataset, leading to a total of an n=13.

We also evaluated differences in the mastery of the three KPIs between instructor sections, using all students who completed the course from each section. Statistical analyses included t-tests on two-sample comparisons, and ANOVA for the instructor comparison. Non-parametric tests would have been more appropriate, given the small sample sizes and the categorical scores. We used a larger confidence level of 10% to account for the many sources of variability and the limitation of our datasets.

V. Results and major findings

Data analysis

Assessment data using research report

Figure 1 shows the assessment results for each KPI, using data collected by the faculty instructors directly based on their knowledge of the entire project and their reading of the final report. The data include all 16 students who completed the class, from all sections.

Based on the evaluations of the full report by the faculty teaching Master's Project, we found that the majority of students (87%) exceeded expectations for the three KPI's evaluated, and that all students met or exceeded expectations.

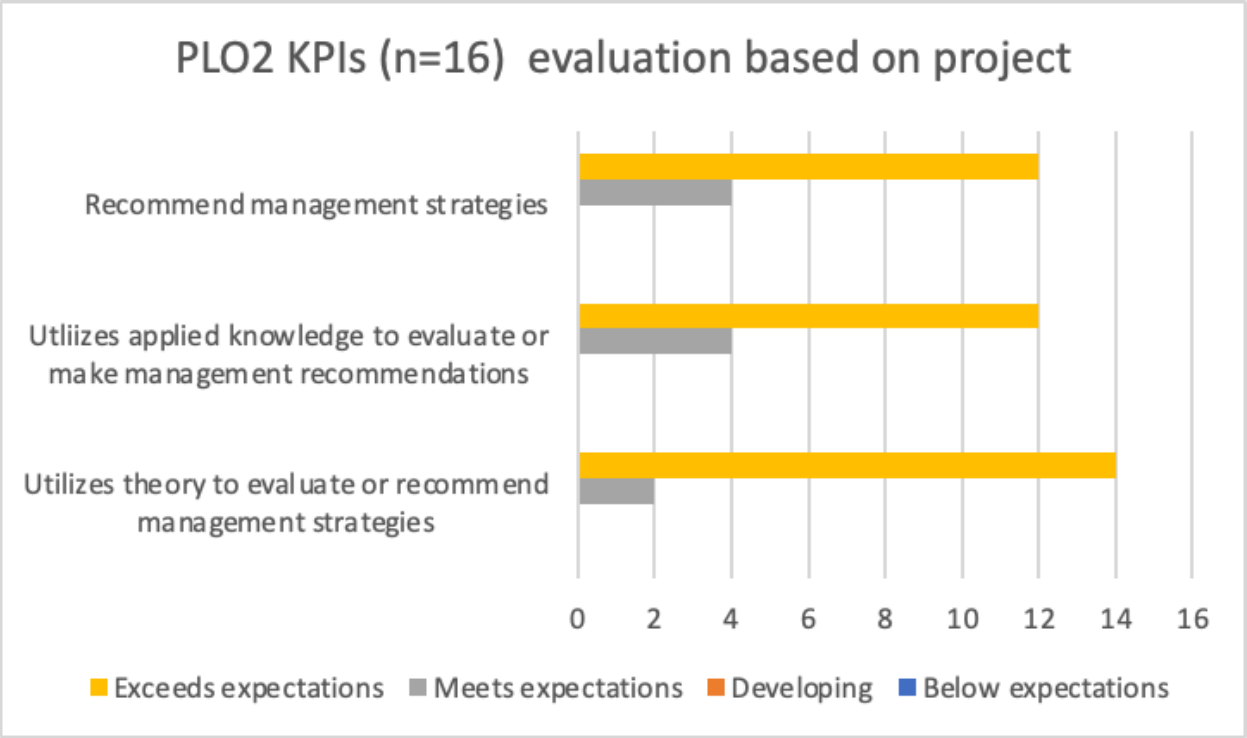

Figure 1. Score distributions for the three PLO2 KPIs using the scores assigned by the instructor based on the full research project report.

We also wanted to evaluate whether there is a correlation between meeting expectations for PLO2 and the overall grade of the Master's Project Students. The hypothesis is that there is a correlation given that PLO2 describes exactly what the students are supposed to do in Master's project.

Figure 2 shows the average sum of the KPIs for all students grouped by the grade they received in the course. A sum of 9 means that all three KPIs received a 3 and therefore the student

exceeds expectations for the PLO2. As can be seen in Figure 2, an average sum of 9 corresponds to an A+. On the other side of the spectrum, the lowest sum of 7.5 indicated that more than two KPIs were not at “exceeding expectations, but the student met expectations in those KPIs, which is a reasonable mapping to an A- for the course.

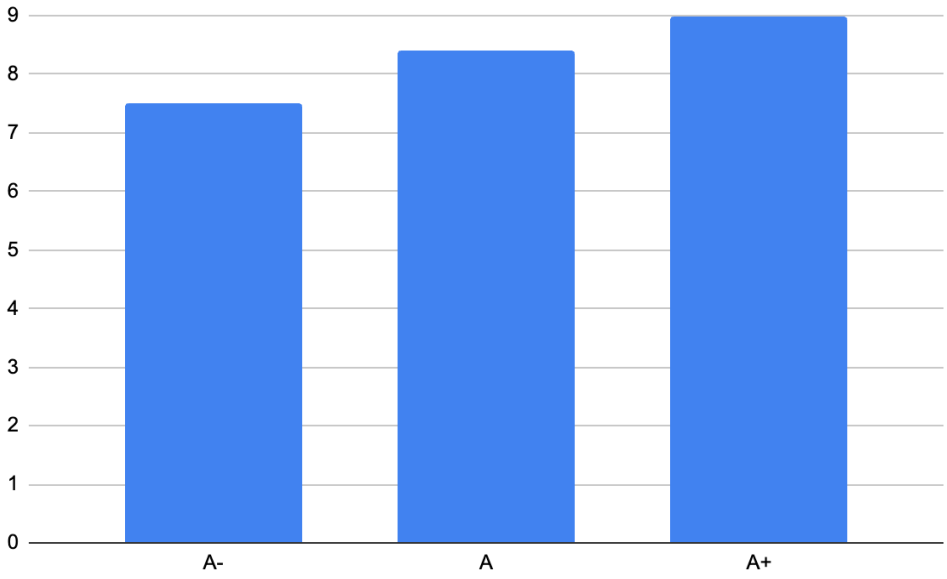

Figure 2. Sum of all three PLO2 KPIs grouped by final letter grade, averaged for all students who received that grade. The KPI data are those provided by the instructor based on the full research project report.

Assessment data using final oral presentation

Figure 3 shows the assessment results for each KPI, using data collected by the independent faculty reviewers who attended the student presentation. From the available data, i.e., student presentations that were attended by at least one faculty member, we excluded three presentations based on the interviewer variability. The hypothesis is that these presentations were presented in a way that made assessment of KPIs difficult to interpret, hence this data were excluded. The rest of the data amounted to 13 data points, 11 of which had a single review, and 2 of which had two reviews with a maximum discrepancy of 1 point. Reviewer 2 was chosen as the most independent evaluation for consistency.

We found that assessment of PLO2 using the oral presentations resulted in slightly different outcomes compared to the assessment of the written reports (Figure 1 versus Figure 3). In the assessment of the oral presentations, we found that similarly to the evaluations of the written report, the majority of students met or exceeded expectations for all three assessed KPI’s. However, the proportion of students that exceeded expectations ranged from 38% to 53% for the three KPIs. The first KPI, corresponding to “utilizing theory”, was the most commonly met at an “Exceeding expectations” level. In contrast, that same KPI was least commonly (46%) met at an “Meets expectations” level, indicating that students do better at demonstrating that they

utilize theory in their presentation, than showing that they utilize applied knowledge, or showing that they can recommend management strategies.

The proportion of students meeting expectations ranged from 46% to 61% and there was one student (7%) who was found to be “developing” for the KPI “recommend management strategies”.

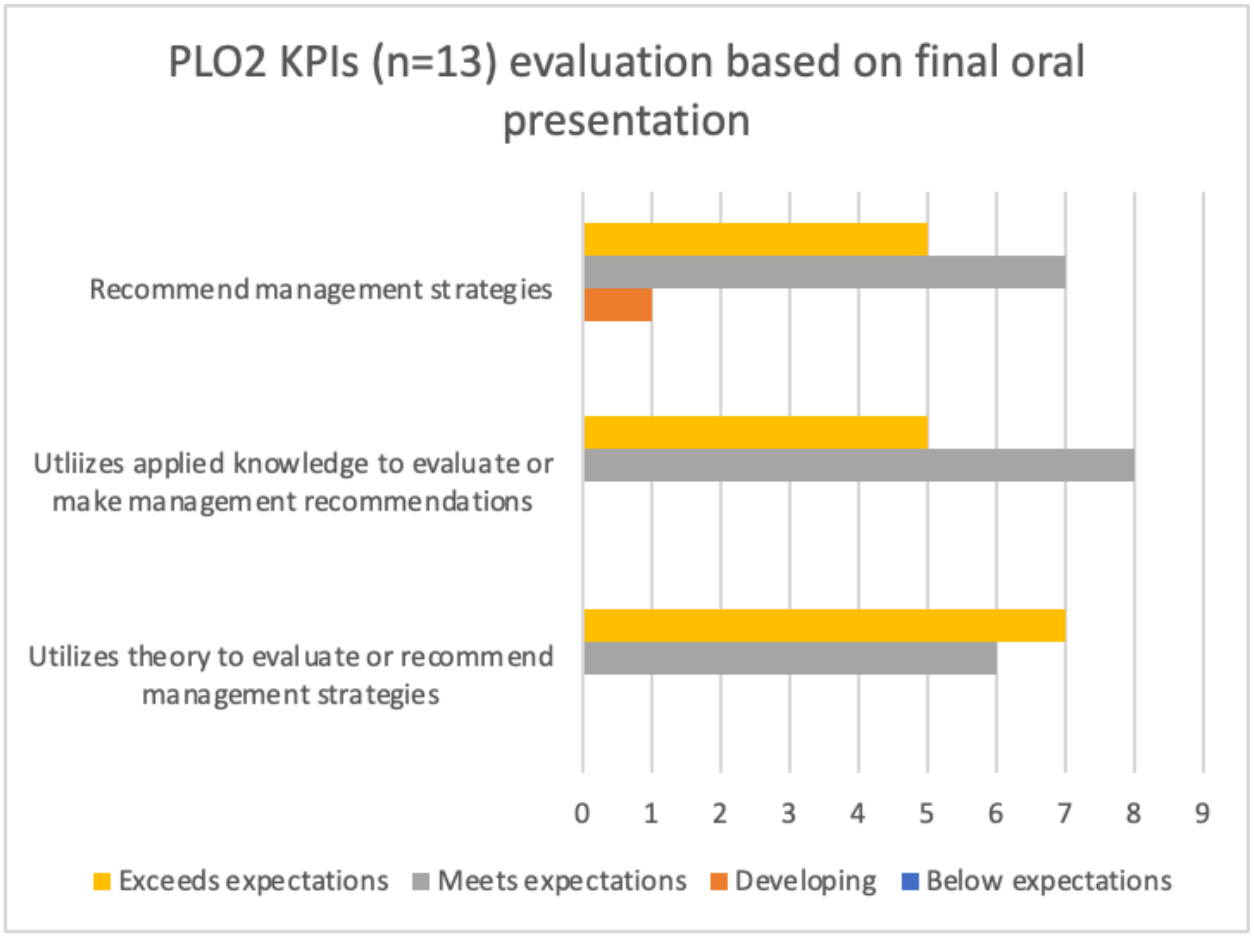

Figure 3. Score distributions for the three PLO2 KPIs using the scores assigned by an independent reviewer based on the oral presentation by the student.

The results of the assessment expressed as proportions for the two assessment methods are shown in the tables below.

Table 6: Proportions meeting and exceeding expectations for each KPI of PLO2 using instructor data and the final written report as the work product

	Utilizes theory to evaluate or recommend management strategies	Utilizes applied knowledge to evaluate or make management recommendations	Recommend management strategies

Below expectations	0%	0%	0%
Developing	0%	0%	0%
Meets expectations	13%	25%	25%
Exceeds expectations	88%	75%	75%

Table 7: Proportions meeting and exceeding expectations for each KPI of PLO2 using reviewer data and the final oral presentation as the work product

	Utilizes theory to evaluate or recommend management strategies	**Utilizes applied knowledge to evaluate or make management recommendations**	**Recommend management strategies**
Below expectations	0%	0%	0%
Developing	0%	0%	8%
Meets expectations	46%	62%	54%
Exceeds expectations	54%	38%	38%

The difference is that more students are seen to exceed expectations when assessment data is provided by the instructor based on the full written report than when assessment data is provided by the faculty attending the final oral presentations. In both cases, all students meet or exceed expectations for all KPIs, with the exception of one student who failed to meet expectations for recommending management strategies.

Differences within and among the assessment of the two work products for PLO 2 may be due to several factors. First, the two work products showcase PLO2 differently, with the more detailed written report likely better demonstrating the achievement of the student more reliably. Second, the focus of research topics differ among instructors. Finally, the evaluators both within the work product evaluations and across the work product evaluations differed. We explore some of this potential variation below by comparing the variability between instructors and between reviewers for a given work product.

Effect of instructor

In this section, we evaluate differences in the scores given by each instructor for each of the KPIs. Instructors are anonymized to enable unbiased interpretation of the data. Figure 3 shows that for the first KPI, the three instructors' scores are similar and as indicated in Table 7, the differences in scores were not statistically significant. The second and third KPIs show more variability among instructors, which is consistent with previous findings that the students' scores showed that these two KPIs were harder to achieve above mastery level. The differences

between instructors are statistically significant at a 10% significance level. Overall, instructors 2 and 3 rated lower on average for KPI2 and KPI3.

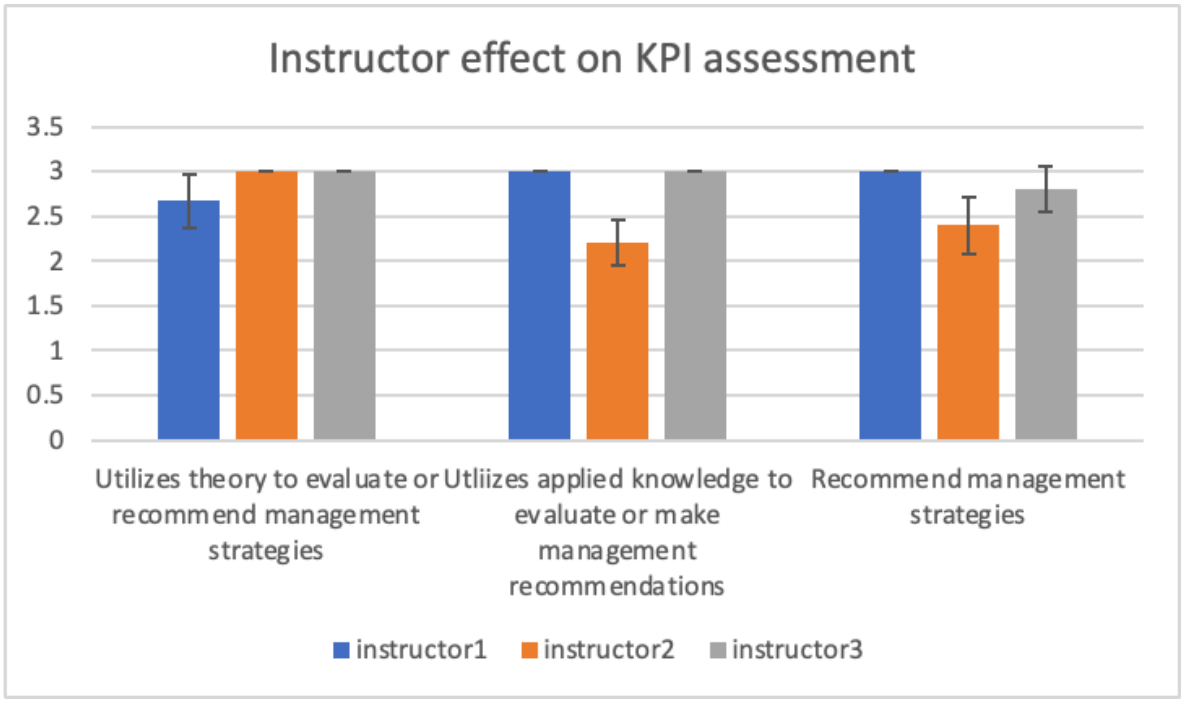

Figure 4. Score distributions for the three PLO2 KPIs using the scores assigned by the instructor based on the full research project report. Scores are grouped by instructor to evaluate potential instructor bias.

Table 8: P-values calculated based on one-way ANOVA analysis for each KPI. A p-value greater than 5% indicates no significant difference between the three instructors.

	Utilizes theory to evaluate or recommend management strategies	Utilizes applied knowledge to evaluate or make management recommendations	Recommend management strategies
P-value for differences between instructors	17.07%	0.02%	7.17%

Effect of reviewer and work product

In this section we evaluate the differences in scores between the two independent reviewers, and between one of those reviewers and the instructor. For this purpose we use data from 5 students that had two reviewers attend their presentation. Table 8 summarizes all of the data for each student. Students are anonymous.

Table 9: Raw data showing differences between reviewers and differences between work products.

Student Name	KPI1	KPI2	KPI3	Faculty Reviewer	work product
Student 1	3	3	2	Reviewer1	presentation
Student 1	2	3	2	Reviewer2	presentation
Student 1	3	2	2	Instructor	report
Student 2	1	3	2	Reviewer1	presentation
Student 2	3	3	3	Reviewer2	presentation
Student 2	3	2	2	Instructor	report
Student 3	1	2	1	Reviewer1	presentation
Student 3	3	2	3	Reviewer2	presentation
Student 3	3	3	2	Instructor	report
Student 4	2	3	1	Reviewer1	presentation
Student 4	2	2	2	Reviewer2	presentation
Student 4	3	2	2	Instructor	report
Student 5	1	2	1	Reviewer1	presentation
Student 5	3	3	3	Reviewer2	presentation
Student 5	3	3	3	Instructor	report

Differences between reviewers

Inspecting the raw data shown above (n=5) , it appears that reviewer 1, identified as Prof. Kokkinaki, generally rated students with lower scores compared to other reviewers (reviewers varied per presentation, it is not always the same reviewer). This is partially supported by the p-values shown in Table 9. For KPI1 and KPI3, Prof. Kokkinaki gave statistically significantly lower scores to students, at a 10% significance level. For KPI2, there was no statistically significant difference between the reviewers.

Table 10: p-values calculated from conducting a one tailed t-test between the scores given on the same presentation by two independent reviewers (n=5). H0: u1<u2 where u1 is the mean of the first reviewer (A. Kokkinaki) and u2 the mean of the second reviewer.

	Utilizes theory to evaluate or recommend management strategies	Utilizes applied knowledge to evaluate or make management recommendations	Recommend management strategies
p-value	9.45%	50.00%	1.63%

The explanation for these scores is as follows. KPI2 has an objective, easily agreed-upon, metric by which it can be assessed. As will be shown in a later section of this report, all evaluators perceive the presence of related applications or studies (i.e., applied knowledge) as an indicator of the student having utilized applied knowledge in their work product. By definition, students review previous studies and applications, whether they are present in the primary literature, or they are case studies or other relevant work. As such, KPI2 is easy to assess and interpret for evaluators.

KPI1 and KPI3 are not as straightforward. Utilizing theory can be demonstrated in different ways, depending on which theory the student is meant to be utilizing, and how well they are able to demonstrate their understanding of this theory during their presentation. Reviewer 1 gave lower scores because she asked a question at the end of each presentation to evaluate how well the student understood the theory behind their findings and used the answer to this question to base their score. As an example: one presentation was about risks from PFAS compounds. The student reviewed the literature and gave a generic overview of risks following some, but not all, parts of a risk assessment framework - when asked what data were used behind these risk assessments and whether they were toxicological or epidemiological data, the student said that this was beyond the scope of the study. If the question had not been asked, one could give the benefit of the doubt to the student and assume that they know what data is behind the findings they are presenting, and thereby give higher scores. This is an example of how having specific guidance on supporting evidence needed in a presentation would help assessors identify the existence of theory and applied knowledge in a student's work.

Similarly, for management recommendations, reviewer 1 considers the recommendation of "more research is necessary" as a non-result. Students who gave a generic, vague recommendation along these lines, were marked very low (1) by reviewer 1. Students who attempted to connect the lack of recommendations to a gap and proposed specific areas of research needed received a (2). Students who actually recommended actionable items received a (3), meeting expectations. This is explaining the rationale used by reviewer 1. Among the other reviewers, there were two faculty not familiar with the Master's Project, and one experienced instructor who has taught the course multiple times. From the data, it is seen that reviewer 2 (not always the same faculty member), always gave the same score to KPI1 and

KPI3, so it is likely that the same assumptions held for evaluating KPI1 were applied to evaluating KPI3.

If anything can be deduced from the discrepancies in the results is that more specific guidance on how to assess the KPIs is necessary. Guidance should include examples per discipline, and reliability of future KPIs assessment data should be improved with a calibration exercise. The following two sections focus on these aspects.

Differences between reviewer 2 and instructor

Based on results presented in the section above, we can conclude that Reviewer 1 employed different/stricter standards for the KPIs. Excluding reviewer 1 data, we next compare Reviewer 2 data and instructor data. Note that both the evaluator and the work product is different in these comparisons.

Results are consistent with the previous section. Even after excluding the lower scores of Reviewer 1, Reviewer 2 had statistically significantly lower results compared to the instructor, as evaluated at the 10% confidence level for KPI1 and KPI3, but not for KPI2.

Table 11: p-values calculated from conducting a one tailed t-test between the scores given on the same presentation by the instructor using the written report and the faculty reviewer using the oral presentation. H0: u1>u2 where u1 is the mean of the instructor/full report

	Utilizes theory to evaluate or recommend management strategies	Utilizes applied knowledge to evaluate or make management recommendations	Recommend management strategies
p-value	8.89%	31.07%	8.89%

Faculty feedback

In this section, we summarize feedback provided by faculty, both instructors and presentation attendees, who provided assessment data.

Feedback by faculty instructor (n=1) on trying to use the KPIs for assessing the final written report.

- *We should define and give examples of key terms -- for faculty and students -- to help us have a common understanding. Some suggestions below.*
- *Examples that could count as management recommendations are policy design, policy implementation, policy evaluation, program or project design, program or project*

implementation, program or project evaluation, operations, outreach, network building, ecological treatment, community engagement, funding, etc.

- *We want students to evaluate management strategies so they need to show the analysis of different options. 'Comparison' is just one type of analysis -- and *how* the comparison is done is important. For example, what criteria are used for the comparison? What is the underlying theory or analytical framework that informs the choice of those criteria? A student researcher may use financial or economic analysis, env justice analysis, geospatial analysis, env impact analysis, fatal flaw analysis, risk analysis, etc. to analyze management options.*
- *A report received by all 3s has the following elements; extensive lit review & frameworks. extensive case studies and analysis of options. specific recommendations tailored to particular orgs & agencies.*
- *A report that received 2 in utilizing theory and 3 in utilizing applied knowledge and providing recommendations has the following elements: solid lit review & frameworks. extensive case studies and analysis of examples. extensive recommendations tailored to particular orgs & agencies.*

Feedback by presentation attendees (n=4) on trying to use the KPIs for assessing the final oral presentation. Organized by KPI.

Comments on using KPI1 (utilizing theory):

Presentations in which the student met or exceeded expectations for KPI1 led to the following comments:

- Discussed background knowledge needed. Gave literature of problem
- Solid framework and methods. Use of literature demonstrated as part of method/results
- Case studies and SWOT methods, used survey data from e-waste
- Used data to provide context > why focus on efforts in Washington. Provided larger-scope rationale. Explained why a management plan based on food availability
- Really well-outlined and clearly communicated. Multi-pronged approach and framework
- Excellent support of all points and very organized framework

Presentations in which the student did not meet expectations for KPI1 led to the following comments

- No references
- Super informed on the issues, I couldn't totally follow a lot of the conversation - but I think I lack the background she has
- Framework to recommend was good - but difficult to follow due to poor organization and relating to each point
- Framework missing clarity at times

Similarities: Faculty identified the existence of framework, data, methods or reasoning/explanation being an indicator of utilizing theory. Faculty identified the lack of

references and supporting evidence to be an indicator of not utilizing theory. Lack of clarity/explanation was associated with not meeting expectations

Differences: Faculty seem aligned. No differences identified.

Comments on using KPI2 (utilizing applied knowledge)

Presentations in which the student met or exceeded expectations for KPI2 led to the following comments:

- Applied knowledge used a variety of source data to do analysis
- Showed clearly a study that relates to question
- Lots of emphasis on one study
- Looked at SWOT analysis and understanding of PFAS to evaluate recommendation options
- SWOT analysis performed > used to demonstrate weaknesses of existing legislation to protect the species. Use of studies conducted elsewhere to apply (or confine / further study for real world applications)
- Great relating theory and background to case study to support recommendations

Presentations in which the student did not meet expectations for KPI2 led to the following comments

- Framework provided. No data analysis. No references
- Data sources provided. Used a lot of gray lit
- SWOT methods not shown. Used understanding of strengths/weaknesses in Ghana for e-waste to make practical / applied recommendations
- Need more detail at times along with references
- Missing some references - but great detail
- Lots of big picture global - missing some support on the local scale
- Well-supported with case studies, but missing some sources to support

Similarities:

- Faculty identified the presence of multiple case studies, references, data as indicators that the student utilizes applied knowledge.

Differences:

- One faculty identified SWOT analysis as a required piece for utilizing applied knowledge. This is atypical, not part of MP requirements.
- One faculty identified lots of emphasis on one study as meeting expectations. This is atypical, synthesis is required.

Comments on using KPI3 (providing recommendations)

Presentations in which the student met or exceeded expectations for KPI3 led to the following comments:

- Good comparison of options, evaluation of uses/public understanding of PFAS, etc.
- Set up background/rationale well for many recommendations
- Gave a good look at habitat data > used to provide support and context for recommendations. Provided examples of methods that have worked elsewhere (e.g., California) and could be applied in Washington

Presentations in which the student did not meet expectations for KPI3 led to the following comments

- too general
- Recommended unrealistic solution. Not a management strategy
- Errors in the environmental impacts slide
- A bit too brief and missing some of the support from earlier in the presentation
- Too brief and didn't fully tie all the pieces together
- Recommendation based strongly on specific analysis - missing synthesis

Similarities:

- Comparison of multiple options is considered important to meeting expectations
- Providing support and context for recommendations, connecting with findings of the research is also important to meeting expectations
- Generalities, lack of elaboration and/or recommending unrealistic solutions are assessed as not meeting expectations.

Differences:

- Faculty appear to be on the same page based on their comments.

Guidance on assessing KPIs per discipline

Faculty feedback given in the previous section indicates that faculty reviewers were largely consistent in their ***reasoning*** for providing the scores they provided, despite discrepancies in the actual scores. It should be noted that faculty reviewers were not provided with any instructions on how to use the rubric or how to interpret the KPIs. However, there were instances where a) faculty felt they lacked the expertise to judge outside of their discipline, b) a faculty member deemed the presence of SWOT analysis as required, and c) faculty assessed the level of detail differently (i.e., assumed the detail was there, even if the student did not elaborate).

Anticipating these differences, the assessment committee and the Program Director had started developing guidance on what are good indicators of meeting expectations for each KPI. This draft guidance is given below and will continue to be developed based on the findings from this assessment and further feedback from more faculty members. The examples provided are meant to help faculty who are doing the *assessing* understand what they are looking for. The examples and interpretations will also *help faculty teaching Master's Project and Research Methods communicate expectations to students*.

We had one faculty from each discipline provide their insight as well as examples for their respective concentration. There is general agreement between three out of the four concentrations on using theory as the means to formulate a hypothesis, and applied knowledge from the literature as a means to test the hypothesis. In the Energy and Climate concentration, where students often focus on policy evaluation, the usage of different frameworks for policy evaluation is the appropriate theory, whereas utilizing applied knowledge is similar to the other concentrations. More details provided below using the faculty-provided text, edited for the purposes of this document.

Energy and Climate

1. utilize **theory.**
This can be utilizing a particular framework or methodology to assess management options or create management options. This is different from KPI3, which is the actual recommendations. For example, a student could use a vulnerability framework based on risk theory to analyze management strategies for sea-level rise. As another example, a student could use a framework of 5 indicators for comparative case study analysis of three cities managing extreme heat, based on theory of thermodynamics, climate science, and environmental justice.

2. utilize **applied knowledge.**
This can be utilizing particular empirical studies or case studies or organizational goals to compare management options or create management options. This is different from KPI3, which is the actual recommendations.
For example, a student could use government agency documents (plans, public hearings, reports) to determine the goals of a program and analyze its performance with respect to those goals. Then they identify gaps and analyze options to address those gaps.

As another example, a student draws upon Traditional Ecological Knowledge (TEK), utilizing TEK to analyze and inform land management strategies. Students are instructed in Research methods that "…we define "success" in applied environmental science as respectfully conducted, partner-relevant research that is accessible, understandable, and shared and that can create opportunities for change (e.g., in policy, behavior, management)."

3. recommend **management strategies**.
This could be project or organization management, program implementation, policy improvements or new policy, management of field surveys, etc. Very few Master's Projects include *business* management strategies.

Ecosystems science

Ecologists frame the concepts a little differently. There is theoretical ecology, empirical ecology, and applied ecology. In Ecology, you often use a ***theoretical framework*** to set up an ***empirical test*** of a hypothesis. If the theoretical and/or empirical data can then be ***applied*** to a practical problem (e.g., something like the cause of Steller Sea lion Decline for example) then we would call that ***applied ecology***.

Theory in Ecology might be related to how species compete for resources, how energy and matter move through food webs and ecosystems, how diversity relates to a variety of factors at different scales, etc. We would want students to use a theoretical framework to make predictions, and empirical data to test those predictions- and then to apply what they learn to solve an issue of importance.

For example, does optimal foraging theory explain Steller sea lion decline? Predictions: 1) Steller sea lions preferentially forage on the most energetically rich fish species (herring) that requires the least energy to obtain. 2) decline in herring may be related to decline in Steller sea lion populations 3) shifts in diet to a less energetically rich forage fish has caused low body mass in Steller sea lions, increasing mortality and reducing birth rates. Then the student would collect or find empirical evidence to support the predictions (1-3) based on the theoretical framework, and then make recommendations based on whether they support their predictions.

Health and Hazards

One example that could be counted as both theory and applied knowledge is if a student has used the literature to come up with expectations/hypotheses for how their system works, and then they had to apply it to a new site or a new species by collecting information from the literature. Example: exposure to estrogenic compounds has led to feminisation of fish in the literature, but now I want to look at this same problem, but in oysters in Australia.

The theoretical part might look at what the mechanisms of toxicity are, whether estrogen receptors are active in mollusks, what concentrations typically cause these types of effects, or that duration of exposure and route of exposure would affect the outcomes. And the applied part

could look at what the concentrations at the site actually are to make predictions, even though no one has yet done these types of studies.

Water management

For water/engineering courses, utilizing theory would be the use of any fundamental science to make a prediction, create a hypothesis, provide an explanation leading to a recommendation. Applied knowledge would be utilizing what others have found based on experimentation and observation, and that would come from the literature review.

As an example: for a green infrastructure project, a student might compare different approaches based on the literature (applied knowledge), but they should have a hypothesis that based on the hydraulics of these systems and the chemistry of the materials used, different performances should be expected (theory). Integrating both is trying to explain consistency or discrepancy between applied knowledge with theory and based on that come to recommendations.

Geospatial Science

For projects heavily reliant on geospatial analysis, students should differentiate between the theoretical frameworks guiding their GIS approach and the applied GIS methods used to perform specific analyses. Theoretical frameworks establish the underlying principles, such as spatial dependency (Tobler's First Law), scale considerations, or spatial autocorrelation, which justify why certain analyses are meaningful or appropriate. Applied GIS concepts, on the other hand, involve the specific tools, data processing, and workflows that operationalize these theories in practice.

For example, in a project estimating contaminant dissipation in a watershed, a student might apply spatial interpolation, which should be guided by Tobler's Law of spatial dependence, to justify their choice of specific interpolation approach to create continuous concentration surfaces from sampled data points. Meanwhile, they may also apply specific GIS methods to incorporate and overlay actionable spatial analysis.

The extent that theoretical GIS components need to be detailed will depend on the project's focus. In actuality, student projects will typically be focused on environmental management and usually detail theories/frameworks related to other concentrations listed above.

VI. Conclusions

PLO2 assessment findings

Using two different assessment datasets, we can conclude that all masters students meet or exceed expectations of all KPIs of PLO2, with the exception of one student who did not meet expectations on KPI3 based on evaluation of the oral presentation. These results indicate that overall students meet PLO2.

Among the three performance indicators, we found that KPI1 and KPI3 are more challenging for students to demonstrate through their presentations compared to full written reports. For KPI1, 88% of students Exceeded Expectations through the written report, while only 50% of oral presentations met the same mark. This is likely due to the short format of the Masters presentation, where students may choose to exclude the content showcasing the use of theory, rather than a lack of a theoretical framework within their Masters project. KPI3 is more challenging because it requires students to extend their critical thinking to propose actionable recommendations connected to the theory and applied knowledge they reviewed in their project.

Improving PLO2

1. **Evaluate the wording of the PLO** and **develop key performance indicators (KPIs).**
   The assessment committee chose to collect data this year without modifying the wording of the PLO and use the faculty feedback from this assessment cycle to evaluate potential changes. The results indicate that all three KPIs have value and need to be separately evaluated, as they target different elements of whether a student's work meets the expectation of PLO2. We concluded that KPI1 is the most challenging for faculty reviewers to interpret and therefore we propose to change the word "theory" with the phrase "theoretical underpinnings of their field". We also discussed that the word "evaluate" is redundant and field specific. In the energy/climate concentration, students do have to evaluate different policies to lead to recommendations; in other concentrations a thorough evaluation of a range of options is not possible, and the recommendations are based on available research findings.

   The proposed PLO2 wording and the corresponding KPIs are given below:

   Original PLO2: Utilize both ~~theory~~ and applied knowledge to ~~evaluate and~~ recommend management strategies for environmental issues.
   Proposed PLO2: Use theoretical underpinnings of the field and applied knowledge to recommend management strategies for environmental issues.

KPI1 is significantly modified to clarify the meaning of the word “theory” as follows:

Outcomes	Exceeds expectations (3)	Meets expectations (2)	Approaching expectations (1)	Below Expectations(0)
Utilizes the theoretical underpinnings of their respective field to propose one or more hypotheses and to formulate their research questions.	Well documented description of theoretical underpinnings of their field, such as highlighting the scientific principles of their topic or use of a framework to analyze their data.	The theoretical underpinnings for the field are provided, but need more detail and/or references.	The theoretical underpinnings for the field are only briefly discussed.	The theoretical underpinnings for the field are not provided.

KPI2 is edited to simplify the wording and intention:

Outcomes	Exceeds expectations (3)	Meets expectations (2)	Approaching expectations (1)	Below Expectations(0)
Utilizes applied knowledge to formulate management recommendations.	The use of applied knowledge is clearly demonstrated, supported by scientific literature, case studies or other synthesis of knowledge.	Applied knowledge is demonstrated, but needs more detail and/or references.	Applied knowledge is only briefly discussed.	Applied knowledge is not discussed.

KPI3 is edited to remove the word evaluate and simplify the wording and intention:

Outcomes	Exceeds expectations (3)	Meets expectations (2)	Approaching expectations (1)	Below Expectations(0)
Recommend management strategies.	Recommendation is well supported by evidence, such as from analysis of data and thorough synthesis of literature, or comparison of options.	Recommendation is supported by some synthesis of evidence or some comparison of options, but not a thorough evaluation of the evidence or no evaluation of options.	Recommendation needs more support. Synthesis of literature or comparison of options not used to recommend strategies. Some generic recommendations were given.	Recommendation is not well supported.

2. **Clarity on the interpretation of the KPIs.**

   We have started to develop guidance for faculty to better understand what each of the KPIs means for different disciplines. We will be providing the guidance to faculty attending the next MP presentation session, and we will collect feedback on the ease of use and interpretation of the guidance.

3. **CLO to PLO mapping**

   The rubrics used to grade student work in Master's project for the full written report and the final presentation are different from the rubric used to assess PLO2. Students are not explicitly asked to demonstrate their mastery of PLO2 KPIs, and therefore they might not focus on these elements. Students are rather told that they are graded on "Content, Organization, Speaking Skills, Documentation, and Slides". PLO2 KPIs all fall under "Content". Better guidance to the student is necessary to understand how they would be providing the evidence (through theory and applied knowledge). Providing management recommendations is a requirement for the presentation, and it is explicitly named in the grading rubric of the final report, but not in the grading rubric of the final presentation.

   Master's project rubrics for both the written report and the oral presentation will be modified to explicitly include criteria that map with the KPIs. Current criteria are generic. The use of theory and applied knowledge, and their usage in recommending management strategies is graded based on multiple criteria, reading as follows:

   Master's project:
   - *"Supporting details and analyses: Statements are supported with specific details, numbers, or tables and figures. There are some nicely done figures or tables, including some original ones." (20/100 pts)*
   - *"Management recommendations: Are appropriate recommendations provided and are they firmly based on material presented in the manuscript?" (5/100 pts)*
   - *"Content and analysis: The paper is a synthesis of different sources, not a drawn out list. The level of analysis is appropriate for an MS paper. The paper has all necessary sections. Sections support the conclusions and answer the research question."*

   Master's presentation:
   - *"Speaker accurately and completely analyzes the topic, drawing upon relevant literature/information and full of quantitative details. Listeners able to develop an understanding of the material. (5/20 pt.)"*
   - *" All sources of facts and examples fully documented and mentioned in the talk. (2/20 pt.)*

As part of our work for the next assessment cycle, we will modify these criteria to be more explicitly mapped to the PLO2 KPIs, so as to provide direct evidence of the student's work meeting both the CLOs and PLO2. Modified rubrics will be developed and tested in Spring 2025. Master's presentation criteria should also be modified to include management recommendations.

4. **Best work product to use**

While the written report provides the most extensive window into the students' work, using it as the work product for assessment presents several difficulties: We found that the instructors almost uniformly assessed all projects and all KPIs as exceeding expectations. The instructors provide substantial feedback and editorial assistance to students as they are developing their ideas and writing their literature synthesis, and therefore may be subject to increased bias in assessing PLOs. Simultaneously, they are closely familiar with the students' work and thought process. Independent assessment of full written reports by faculty reviewers are impractical as they would place additional strain on faculty members already managing significant workloads. On the other hand, oral presentations also have shortcomings for assessment. While students also receive feedback, presentations have to be delivered live to an audience, questions need to be answered, and the student has the ability to demonstrate their knowledge through the presentation and Q&A session. This short-format makes it challenging for students to clearly and effectively present the entirety of their work, let alone demonstrating each component of PLO2 (theoretical underpinnings, applied knowledge, and recommendation of a management strategy).

Overall, we conclude that both products are important to have when assessing PLO2. We think that the instructor-based assessment gives a fuller picture of the students thought process and intentions, while the independent reviewer feedback may underestimate the students performance given the limited duration of the presentation. We think the truth is somewhere in the middle and we want to continue collecting and analyzing both products. The importance of PLO2 justifies the additional data collection and analyses to ensure that students are meeting expectations.

To make the collection of data more manageable the following processes are put in place:

- Alignment of PLOs and CLOs (see point 3) will allow the collection of instructor data directly from Canvas.
- The program manager will be collecting all MP reports and presentations as standard practice going forward to allow for evaluation of PLOs using multiple-year data, rather than just the MP work products of the assessment year, to allow proper statistical analyses.

- Faculty-reviewer data will be given specific guidance (see point 2) on how to assess PLO2, and a calibration exercise will be developed before data collection.
- Faculty-reviewer data will be collected more systematically, by allowing faculty to choose the presentations they attend ahead of time, and by enabling a hybrid format for the final presentations conference.

5. **Curricular improvements in Research Methods:** Starting Spring 2025, we will implement changes in Research Methods to clearly explain to students how to interpret theory and applied knowledge in the different fields of environmental management, and how to evaluate and propose recommendation strategies.

VII. Closing the loop

Feedback from the FDCD

Last year's feedback encouraged the MSEM program to continue doing assessment using similar methodologies, and to continue improving our processes. This year, we focused on improving our processes for evaluating PLO2.

Continuous improvement

The data included in this report have been shared with the department. Once we receive feedback from the FDCD, we will proceed in conversations around finalizing and approving the proposed wording of PLO2 and the corresponding KPIs, collect feedback on the guidance developed for faculty, enhance content of Research Methods to teach students how to communicate the use of theory and applied knowledge in their work and finally formalize new rubrics for Masters project and communicate the changes to students completing both Research Methods and Master's project.

Given that the two work products discussed in this report are crucial for cumulative assessment of graduating students from MSEM, we will be collecting all written projects and all oral presentations in a central program repository, different from the library repository, going forward. This way, we will be able to use these work products for assessing multiple KPIs over multiple years. We are also testing other process changes as outlined in the section "Conclusions".