

iPlan/LEM Pilot Project Final Report

Report Summary

The Massachusetts Audubon Society has completed Phase III of the Rhode Island Assessment of Environmental Literacy (RI-AEL) project. While there were challenges in throughout this phase of the project, including a global pandemic and change of project management, we believe that this report will demonstrate successful completion of the intended outcomes of the project. The project was conducted by Mass Audubon upon the recommendation reached as a result of Phase II of the RI-AEL project. It was determined that the University of Wisconsin-Madison's Epistemic Analytics' Local Environmental Modeling (LEM) simulation, named *iPlan/LEM*, has the highest potential for use as a scalable digital assessment of environmental literacy. However, there would be significant investment needed to make the necessary game modifications and validations. Before embarking on this effort (Phase IV), it was necessary to establish the usability of the existing iPlan/LEM program by teachers and students. Phase III was managed by Mass Audubon, in collaboration with Siebert-Evenstone Research Consultants (SERC), LLC, who is on the team at University of Wisconsin-Madison's Epistemic Analytics and involved in the previous two phases of RI-AEL.

With generous support from both the Pisces Foundation and the Rhode Island Foundation, RIEEA contracted Mass Audubon to conduct the following activities:

1	Develop a presentation for the RIEEA team to use when meeting with teachers and administrators interested in participating in the pilot assessment.	Page 3
2	Support RIEEA in teacher meetings to help facilitate an agreement to participate in a pilot assessment.	Page 3
3	Administer the pilot of iPlan/LEM in 6-8 Rhode Island classrooms utilizing the feedback from the Community Forums.	Page 3
4	Provide stipends of at least \$250 to each teacher who participated in a focus group.	Page 3
5	Gather and analyze data from teachers' focus groups and students' surveys and focus groups.	Page 3
6	Collaborate with RIEEA and the University of Wisconsin to develop a vetted list of potential funding sources and collaborators for Phase IV of the RI-AEL.	Page 12
7	Develop a work plan for writing and submitting a proposal(s).	Page 15
8	Pilot iPlan/LEM as part of RIEEA's Youth Leadership Retreat.	Page 16

Project Design Summary

This RI-AEL Pilot Project consists of four phases as described here and in previous reports. The Phase III process was initiated by RIEEA who recruited teachers from 9 middle and high schools across the state of Rhode Island. The process began in early 2020 and extended into the fall of that year. Once teachers agreed to pilot the program, the remainder of the process was led by Mass Audubon. The Mass Audubon Project Manager then met with each teacher, in person or virtually, to orient them to the iPlan/LEM program, collaborated on how the pilot project would integrate into in their classroom curriculum, and responded to questions they had about the process. At this stage, teachers were then introduced to the Mass Audubon teacher-naturalist who facilitated the iPlan/LEM classroom sessions with the school students. The Mass Audubon teacher-naturalist also worked with the classroom teachers to develop and implement a wrap-around lesson plan to help the iPlan/LEM pilot fit into their curriculum. We believed it was important to provide this service to these classroom teachers, so they did not have to sacrifice learning time for pilot testing time.

The pilot tests consisted of 3-5 sessions: introduction to iPlan/LEM, demonstration of the software, facilitation of student implementation, and a wrap-up which included student presentations of their maps. Typically, the sessions took place on consecutive days to ensure continuity. There was one case where the sessions had to be scheduled across a period of two weeks due to changes in the school's virtual class schedules.

Upon the completion of the pilot, students were provided an online survey consisting of multiple-choice questions. The Mass Audubon Project Manager also conducted 3 focus groups for 18 students within 30 days of the completion of their programs. Students were selected by their teachers to participate in one of three scheduled virtual focus group sessions. Teachers also participated in a focus group session led by Dr. Daphne Minner. The results of these assessments are described in detail in Section 5.

Concomitantly and finally, Mass Audubon worked in consultation with the University of Wisconsin-Madison's Epistemic Analytics staff, Amanda Siebert-Evenstone (SERC, LLC) to identify and introduce the RI-AEL Phase IV Project to academics and researchers with expertise in education evaluation and environmental education research. The nature of these discussions and the recommendations for funding of Phase IV are detailed in Sections 6 and 7.

Phase III Activities

1. Develop a presentation for the RIEEA team to use when meeting with teachers and administrators interested in participating in the pilot assessment.

Mass Audubon collaborated with RIEEA to develop a <u>PowerPoint presentation</u>, used to orient recruited teachers to the iPlan/LEM program. The presentation includes screenshots of the iPlan/LEM program, descriptions of various facets of the game, and a short tutorial of how it works.

2. Support RIEEA in teacher meetings to help facilitate an agreement to participate in a pilot assessment.

RIEEA was the primary agent for securing teacher participation in the pilot assessment. Mass Audubon supported this effort by following up with RIEEA's initial conversation with an orientation to the iPlan/LEM tool and the pilot project as a whole. Despite the challenges that the COVID pandemic presented to schools, only three teachers who considered participating did not follow through to complete the pilot in their classroom. All others who initially agreed to pilot iPlan/LEM in their classroom completed all stages of the program. In total, 10 teachers participated in the pilot assessment with one teacher implementing the pilot in both the spring and fall of 2020.

3. Administer the pilot of iPlan/LEM in 6-8 Rhode Island classrooms utilizing the feedback from the Community Forums.

Mass Audubon facilitated the pilot assessment in 20 Rhode Island classrooms in 9 schools 2020. In the spring of 2020, Mass Audubon completed 5 of those programs with 2 teachers at 2 schools. Mass Audubon was able to conduct all sessions for one school in person; the other school was conducted remotely. The remainder of the interested schools had to be delayed to the fall of 2020 while schools were transitioned to a virtual and/or hybrid school day due to the COVID pandemic. Each classroom participated in 3-5 sessions, depending on their needs and capacity of time.

4. Provide stipends of at least \$250 to each teacher who participated in a focus group.

Ten teachers participated in the focus groups that took place across four days in July, late November and early December. One teacher (Metropolitan Liberty) piloted iPlan/LEM with students from his and his colleague's classes, so only he participated in the focus group. Stipends of \$250 were processed for each of these teachers and completed by December 23, 2020.

5. Gather and analyze data from teachers' focus groups and students' surveys and focus groups.

In this section, we present summary findings from teacher focus groups, student surveys, and student focus groups.

Teacher Focus Groups

Dr. Daphne Minner conducted focus groups with all 10 participating teachers. Below is a summary of responses to each question. Dr. Minner's notes from the focus groups can be found <u>here</u>.

Table 1: How did you use iPlan/LEM with your students?

In Phase III, teachers made it possible to beta test the iPlan/LEM platform across 6 different content areas, in 24 sessions with a total of 321 students for 2,185 hours.

Class/Unit	# teachers	# sessions	# students	Beta testing hours
Ecology	2	3	52	495
	1	5	28	80
Biology/Heredity	2	4	134	804

General science	3	3	55	495
Intro to STEM	1	4	22	176
Horticulture	1	3	12	27
Environmental science	1	4	18	108
TOTAL	11*	24	321	2,185

* One teacher piloted with two different cohorts of students; one in spring and the other in fall 2020.

How easy or hard was it to use?

Three teachers reported modest issues with students being able to use their Chromebooks to access iPlan/LEM; however, they were able to work through the technical issues. Once those initial technology issues were resolved, all 10 teachers reported that iPlan/LEM was easy to use.

One teacher's students had challenges with understanding the land use types and said, "Trying to figure out which land use type was useless." This statement runs contrary to the goal of the simulation and suggests the teacher and/or students would have benefited from more or different support in preparation for or during their investigations.

Could you imagine administering it on your own/using it again?

All but one teacher could see themselves integrating iPlan/LEM into future classes, though there were some concerns expressed.

One teacher reported that iPlan/LEM wasn't comprehensive enough for her needs. She had to spend extra time obtaining supporting content for her students. "We had to go outside the system to get the content. I went to Ted talks to have students get information on netzero, the effect of cities vs. green areas on the ozone layer, identifying various layers of the atmosphere, and the different chemicals that affect those layers. In working with different stakeholders, students also needed more information about those stakeholders (demographics), as well as more information about wetlands and how they functioned." This feedback suggests that iPlan/LEM may need modifications to support student investigations about land uses, stakeholders, and indicators. Teachers might want versions that are more complex and provide more resources, activities, or difficulty than the current version.

Three of the teachers have used an earlier version of iPlan/LEM, called Land Science, in the past and have plans to incorporate iPlan/LEM into future classes including field trips. One of these teachers who had been using Land Science indicated that he preferred that more extended experience to the current version.

Another teacher stated that he felt the rigor of iPlan/LEM to be appropriate for his high school students and that in the future, he will integrate iPlan/LEM into his climate change unit.

How did the students engage with the iPlan/LEM simulation?

The majority of the implementations were facilitated virtually by Mass Audubon, which posed some challenges in engagement and detectability in engagement. Teachers reported that the first session (iPlan/LEM introduction) was the least engaging of the sessions, but all teachers reported that their students appeared to be more engaged when they were conducting the simulation. "Initially finding their house on the map was key to getting them engaged with the program."

One teacher participated in the pilot in the spring and the fall of 2020. She reported that her students were far more engaged in the fall when her students were back in the classroom than when they were distance learning in the spring.

In the classroom where all of the implementations occurred in person, the teacher was able to hear the students talking and directly observe how they were interacting with the simulation. She reported that most of her students spent their time just clicking in an effort to get as many of the stakeholders to agree as possible.

How many students do you think were just clicking different options to see what would happen (rapid clicking) versus engaged with the content in a more deliberative way (reading the items on the screen)? How did you know this was happening?

Six teachers reported that the majority of their students appeared to be engaged with the content rather than simply clicking through the options. Evidence of this engagement included students having conversations with each other about making the stakeholders happy.

Four teachers described their students as being most concerned about pleasing the most stakeholders, therefore clicking different options until they get the best result possible. In these cases, the teachers made an effort to have conversations about the various decisions students made saying, "We had to have more in-class discussion for the students to get the connections depicted in the program." This suggests that the simulation could be updated to provide more opportunities for explanation and reflection in order to understand the interconnected nature within the model.

What did the students find particularly interesting in the iPlan/LEM simulation?

Students were most interested in debating the decisions in the simulation and discussing the concept of high-density vs. low-density housing.

Do you think iPlan/LEM could be used as an assessment in your classroom? Why/why not?

The results from this question are split. While all teachers think that iPlan/LEM could be used as an assessment in some way, they all agree that changes would need to be made. This is consistent with the results from the previous phase of this study.

Five teachers believe it could be a measure of learning in its current state, particularly as indicators of problem-solving and data literacy. As one of these teachers states, "I think this

could be a great assessment in an environmental class—perhaps be used for seniors to receive an Environmental Science Endorsement in RI."

Five teachers reported that iPlan/LEM would not function well as an assessment in its current form.

Teachers identified the following as changes that would improve iPlan/LEM's use as an environmental literacy assessment (See Table 2).

Information Needed	# Teachers	Functionality Needed	# Teachers
Record of change history across simulations	1	Ability for students to share map	3
Local case studies	1	Ability to track student thought evolution	8
More content about indicators and land uses	2	Lesson plan integration	1
Job impacts	1	Ability to include evidence from stakeholders	3
		Written argument/ environmental impact statement in order to assess science and engineering processes	4

 Table 2. Summary of recommended changes by teachers.

The two most common recommendations were the "ability to track student thought evolution" and adding a "written argument/environmental impact statement in order to assess science and engineering processes." These two recommendations align with the underlying goal of the project to assess student problem-solving as a function of their environmental literacy. Additionally, Phase II also recommended adding a written component to iPlan/LEM which will provide important information about student argumentation, reflection, and student reasoning.

Some comments of note:

"This is not an assessment of environmental literacy but let's them know 'life is gonna suck.'...the simulation is more about the civic process and how to plan a city than how the environment works."

"The simulation nearly gets the mark right...However, iPlan/LEM is not a great measure of environmental literacy. Students couldn't explain why changes made the environment behave in different ways."

"Students do learn about the environment, but not enough for certification."

This feedback from teachers is not surprising, as they support the conclusions reached by the Mass Audubon and consultants from the University of Wisconsin-Madison's Epistemic Analytics that conducted Phase II of this project. Primarily, this feedback suggests the need for students to reflect and develop justifications for their decision-making. By externalizing and explaining their choices, students would engage in the critical reflection necessary to understand the complexity of these socioenvironmental issues.

Student Data

While the above information was obtained from teachers administering the simulation, the following information was gathered from students who engaged in the simulation and obtained through student surveys and student focus groups.

Student Online Survey

Upon completion of their class's pilot implementation, students were sent an online survey that asked them about their experience using iPlan/LEM. We obtained 281 student responses from 9 schools. Below we report answers to four questions about engagement and feasibility of iPlan/LEM.

The majority of students responded favorably to these questions. Of specific interest is their response to using iPlan/LEM as a form of assessment compared to regular tests. Fifty-nine percent (59%) of the students (n = 168) agreed or strongly agreed that iPlan/LEM would make for a better test than traditional assessments (see Figure 1). Similarly, the majority of students agreed or strongly agreed that iPlan/LEM was fun to use (56%), and they were focused during the simulation (63%). We were able to obtain further insight into this response during the focus groups.

Figure 1. Summary of student survey responses (n = 281) about feasibility as a test, ease of use, enjoyment, and focus.



Student Focus Groups

Our student focus group sample consisted of 12 students from grades 8 (n = 2), 9 (n = 6), and 11 (n = 4) who primarily engaged with iPlan/LEM as a part of their science classes. Students joined a web conference and were called on to answer questions about the usability of the tool, feasibility of the iPlan/LEM as an assessment, tool navigation, and learning outcomes.

Usability

One of the primary goals of this phase was to assess whether or not students and teachers were able to use iPlan/LEM and if they enjoyed using the tools. Students were asked to provide an open-ended score on a scale of 1 to 5 for the following three prompts:

How engaged you were with the program? How easy it was to use? Using iPlan/LEM was fun

Across the three questions, students rated iPlan/LEM on average a 4 out of 5 (see Figure 2) with all scores in the range of 3 to 5. This is a positive outcome, as no students rated the program as a 1 or 2 in any of the categories. Overall, students found iPlan/LEM to be fun with 11 students rating iPlan/LEM a 4 or higher.

Figure 2. Summary of student focus group responses (n = 12) for engagement, enjoyment, and ease of use.





For both engagement and ease of use, the students provided a larger spread of answers. Students rated their engagement fairly high, with 9 of the 12 students reporting scores of 4 or more. One student added that they continued to play iPlan/LEM after the session, "I'm competitive so I spent a lot more time after school trying to 'win'."

However, the student ratings of ease of use were lower. In follow-up questions, students primarily expressed frustration with how difficult it was to please stakeholders. Students often described the ease of use regarding playing and "winning" the game rather than discussing any technical problems they may have experienced. Only one student expressed a technical issue that zooming within the game was difficult. This result is promising because it indicates the game was usable and engaging; the "struggle" students experienced was an intentional attribute of the problem-solving aspect of the learning activity.

Feasibility

The goal of this project is to build an experiential assessment tool so we asked students, "Would you prefer iPlan/LEM instead of a regular test?" and "How does iPlan/LEM compare with your current tests?" Overall, 11 of the 12 students agreed that they would prefer iPlan/LEM as a test rather than traditional testing. The one student that did not agree did not "understand how iPlan/LEM could be used as an assessment."

Students expressed overwhelming support of the idea of a non-traditional assessment. Students liked that iPlan/LEM was "fun", "better than a test", "more creative", "userfriendly", "more interesting", and "more real-world". For example, students appreciated that "with iPlan/LEM, you can get feedback and get visual understanding" and "because there is more opportunity to work through things instead of just trying to find one right answer." In each of these answers, students address the experiential and interactive nature of iPlan/LEM which is promising for this project.

At the same time, students were somewhat reluctant about using this sort of tool for grading because they were worried "it would be hard to get a good score." If moving forward with iPlan/LEM as an assessment, it would be important for both students and teachers to have a clear understanding of what was being assessed and how. Clarifying the goals and intentions of the simulation could be one step to address this.

Tool navigation

As we begin to turn this learning simulation into an assessment tool, we are interested in how students navigate the program. Since navigating within iPlan/LEM is the assessment, how they navigate and what they click are important indicators of their problem-solving process. To teach students about important pieces of the model, we have embedded resources that explain land uses, indicators, stakeholder groups, and stakeholder preferences. These resources provide more contextual information about the key features of the iPlan/LEM modeling systems; however, we were curious if students read these resources to inform their decision-making. Therefore, we asked students "did you mostly look and click or read the information?" Across the students, half of the sample reported that they mostly clicked through the tool without explicitly accessing resources (n = 6). At the same time the other half of the sample, either read the resources (n = 3) or engaged in

both reading and clicking (n = 3). In follow up studies, it would be important to check student reporting of their tool use against the underlying clickstream data to see how these two relate or differ.¹

One student explained, "Read; I memorized and tracked percentages." One goal of the design of iPlan/LEM was to make all components necessary for the experience. Although this student explicitly read the resources and used the data tab to gauge indicator changes, we would not want to require students to do either of these practices unless it helps their problem-solving. Another student said that they initially used the clicking strategy but found that they needed the resources, they "clicked at first until things didn't make sense, then read and figured it out." As this student reported, the resources were helpful and necessary for their decision-making. Further investigation is necessary to map choices in iPlan/LEM to problem-solving strategies to understand how and why students are navigating the tool.

Students were also asked, "If you could change anything, what would it be?" Across the students, the most common change suggested by the students was to remove the "stakeholder who doesn't like butterflies." While the simulation includes such a character that may seem unrealistic, in the real world, people often argue against species in favor of social or economic issues. Moving forward, we could review the stakeholders to ensure representation of characters and how these characters are portrayed.

Learning outcomes

Finally, we asked the students questions regarding the learning outcomes of the tool. Specifically, we asked:

What did you understand as the goal?

Using iPlan/LEM taught me more about:

What did you find particularly interesting?

What did iPlan/LEM help you understand and how?

When designing iPlan/LEM, our goal was to have students construct, investigate, and solve simulated urban planning problems by examining the environmental and socioeconomic impacts of land-use decisions in their own local contexts. In this way, iPlan/LEM is a model-based reasoning activity for exploring the complex interrelationship of social and ecological systems.

Across the sample, 11 of the 12 students discussed the causality and/or complexity of the iPlan/LEM model. Therefore, we would hope and expect students to discuss interconnectedness, causality, and complexity in their descriptions of the goals and their understanding of the tool. Having almost all of the students express the fundamental learning activity is very encouraging for our project.

¹ For instance, in previous work we found that participants using iPlan/LEM would explicitly say they were using an infill development strategy while developing much of suburbia—a decidedly suburban sprawl approach.

Of these students, 7 explicitly discussed cause and effect, an important science concept and one of the Crosscutting Concepts outlined in the NGSS. For example, one student said that iPlan/LEM taught them about "cause and effect; how every action has positive and negative impacts." Another student said, "causes of greenhouse gases, how to prevent and reduce [them]." In each of these statements, students are expressing that iPlan/LEM provided a way to make changes in a system and see their associated effects. Further, in each of these examples, the students express a personal stance towards their goals in the activity. In the first quote, the student talks about the positive and negative impacts of their decisions indicating that not all changes in land use will result in positive outcomes. Similarly, the second student expresses a stance towards changes that specifically prevent or reduce greenhouse gas emissions. Another student more specifically described these relationships saying, "how adjustments in the map resulted in different stakeholder decisions, changes in indicators." Each of these statements relates to ideas of complexity, where actions occur in a system where many parts are affected by a single action.

Other students also responded to these questions expressing the complexity within the iPlan/LEM problem. For example, one student brought up model complexity by saying, "how much thought goes into urban planning, and how complex it is". Across the small sample students expressed how iPlan/LEM increased their awareness of the interconnected and multifaceted nature of socio-environmental problems.

At the same time, using this model also highlighted limitations to environmental protection. Students expressed frustration saying, "that it was easier to make greenhouse gases worse than it was to reduce them" or that "it was really hard to reduce the temperature." In this way, students were able to learn how changes in land-use affect indicators, however, the reduction of environmental effects within a system is limited by what already exists. Future designs could consider options for mitigation and other measures that address this problem.

Finally, those that read seemed to offer more nuanced and specific responses across their focus group answers. For example, students who read were more likely to refer to ideas such as "heat islands", "heat advisory days", and "greenhouse gases" while those that did not read tended to use more summary terms such as "pollution". Future investigations would need to be conducted to understand this observation and ensure there were not any confounding factors (i.e. those that read were from AP classes; those that read were required to read by their teachers).

Summary of Data Analyses

Based on the aforementioned data, we believe we have demonstrated the feasibility of using iPlan/LEM as an assessment of environmental literacy. Through focus groups, surveys, and other discussions with participants, we have shown that iPlan/LEM is easy to use, engaging, and could be used as an assessment. However, there is also more development necessary to improve student understanding, explanations, and problem-solving as well as more work to identify student problem-solving strategies and correlate those thought processes with actions in the tool. As such, we recommend that we proceed with Phase IV of the RI-AEL Project.

6. Collaborate with the RIEEA and University of Wisconsin (SERC, LLC) to develop a vetted list of potential funding sources and collaborators for Phase IV of the RI-AEL.

Mass Audubon and the University of Wisconsin-Madison's Epistemic Analytics' consultants provided the following conclusion upon completion of Phase II of the RI-AEL Project:

iPlan/LEM is the only tool that meets all of the tool requirements as well as environmental literacy components requirements. That being said, we would need to modify iPlan/LEM to meet the components and underlying activities for environmental literacy. While the iPlan/LEM met all literacy and technical requirements, iPlan/LEM currently does not address reflection and taking action.

First, we would need to add mechanisms to foster student reflection so that students would provide a more explicit explanation for the reasons behind their actions. These explanations would allow iPlan/LEM to achieve the "reflect" category from the environmental literacy components and encourage students to make the connections necessary to understand the relationship between land uses and socio-environmental issues. Second, iPlan/LEM currently does not allow students to show or express their intention to take real-world action. iPlan/LEM could add an Environmentally Responsible Behavior survey to assess current and future behaviors.

While iPlan/LEM may be a useful tool for identifying student decision-making and changes in learning, there is a difference in making claims about learning activities and making claims about student literacy at scale. Validation studies check to make sure that assessments are not systematically biased in some way that may provide privileges to some students or disadvantages to others. Validation studies also check for the assessment for various types of validity. We would want to ensure that there are no threats to construct validity - that is, that our assessment tool has the ability to make inferences about unseen traits such as environmental literacy. Additionally, we would want to ensure the iPlan/LEM tool has good ecological validity by making sure the assessment correlates with other external measures or expert ratings of Environmental Literacy.

Using the data gathered in Phase III and considering the recommendations from Phase II, Mass Audubon and SERC, LLC developed a list of potential research partners for Phase IV of the RI-AEL. The list was based on our experience at conferences, our familiarity with the literature, and recommendations from other researchers. Our original list consisted of professors at 9 universities including the University of Connecticut, Cornell University, University of Florida, Stanford University, Duke University, and the University of Minnesota. This list shifted over time based on our further investigation into the research interests of these individuals. In total, the Mass Audubon/SERC team contacted 9 researchers and had virtual meetings with 7.

We also created a <u>summary document</u> to use when requesting meetings with these potential collaborators.

Meeting Summaries and Recommendations

Dr. Marianne Krasny from Cornell University was our initial conversation. While Dr. Krasny found the project compelling, she did not see this as a fit for her interests. She recommended that we contact Dr. Marc Stern, Dr. Charlotte Clark, and Dr. Kathryn Stevenson, Janice Dickinson, Dr. Joe Heimlich, and K.C. Busch. She also indicated that the National Science Foundation (NSF) will be the most likely to fund the research.

Rupu Gupta, a researcher at Knology expressed a tremendous interest in being involved with the RI-AEL Project. Rupu has extensive experience in social psychology and program evaluation and sees that this research would yield important research for social good. She has conducted evaluation research with Johnny Fraser and Joe Heimlich on various museum and aquarium-based programs. Rupu also believes that NSF is the most logical funding source for the next phase of this project. Knology has a strong NSF legacy that they could bring to bear. Rupu also indicated that she thinks the Pisces Foundation might be interested in funding this kind of research. In addition, she recommended we look into the William T Grant and Spencer Foundations.

Dr. Julie Ernst of the University of Minnesota was impressed with the iPlan/LEM tool and its alignment to NGSS and the ability of the program to be used as an assessment as well as a learning tool. Dr. Ernst may be interested in partnering on this project at a later time. The questions she posed led to a rich discussion about the metrics and data that iPlan/LEM can generate, and how that relates to the testing of the various domains of environmental literacy. Dr. Ernst also believes NSF, either under their K12 or informal science programs, would be a target for funding. She also mentioned the North American Association for Environmental Education (NAAEE) and the Pisces Foundation as potential funders. She indicated she might be able to provide us with a list of private funders that might be interested in funding this kind of research. Dr. Ernst encouraged us to also look into geography education for funding. She believes iPlan/LEM fits in well with geography in terms of standards. It may open more doors for us for both research collaborators and funding.

Dr. Marc Stern of the University of Virginia and Dr. Bob Powell of Clemson University both met with us to discuss iPlan/LEM. They have been collaborating on environmental education evaluation for many years. They are intrigued by the research proposal and expressed interest in collaborating in the research, though they did not feel they were in a position to be the lead investigators on the project. Both Dr. Stern and Dr. Powell mentioned the difficulty in measuring an important variable in environmental literacy: taking action. This prompted a productive conversation about re-integrating reflection as a part of the iPlan/LEM program. This core component of Land Science has not been integrated into the iPlan/LEM version yet but could be the most realistic measure of intent to take action. During our meeting, we discussed the idea of using the 'talk-to-text' feature that may make it easier to use so that typing a long reflection statement would not become a barrier to important data collection. We also discussed ideas for validation studies and the possibility of triangulating iPlan/LEM data with their environmental literacy scale. This was a very fruitful conversation; Dr. Stern and Dr. Powell have a lot of ideas that could make the next version of iPlan/LEM even more robust. They recommended seeking funding from NSF, despite the notion that NSF tends not to like to keep funding the same project over time. No

other ideas for funding were suggested. They have asked us to keep them posted on the next steps.

K.C. Busch from North Carolina State University also had a virtual meeting with the Mass Audubon and SERC. Dr. Busch has been looking at model-based reasoning and working with some citizen science programs to determine if their programs collect any "bycatch" that are indicators of environmental literacy. Dr. Busch finds the RI-AEL project quite interesting and while she does not necessarily see herself directly involved with the research, she did recommend that we integrate into the research and investigation how iPlan/LEM and the existing paper tests compare to each other. The paper tests developed by Dr. Tom Marcinkowski (Florida Tech University) and others have been validated and accepted by the field as "tried and true." Dr. Busch suggested we also consider adding social studies researchers into the project, as they can pick up on where environmental education and environmental science leave off. She mentioned Dr. Jeremy Stoddard of the University of Madison and Dr. Paula McAvoy at NC State as people who we may want to communicate with about the areas of deliberative dialogue and how students value social and environmental aspects of life. Lastly, Dr. Busch suggested we look into NOAA environmental literacy grants and the Burroughs Wellcome Fund for STEM literacy for potential funding sources.

Mass Audubon and SERC also had a conversation with Dr. Kathryn Stevenson of NC State. Dr. Stevenson is very intrigued by iPlan/LEM and the potential in using it as an EL assessment. She would like to be on the list of researchers invited to participate, with the caveat that she may have to back out early on in the event she doesn't see a good fit. Like the others, she mentioned NSF as a potential funder. She also mentioned the Pisces Foundation but urged us to at least talk to Stanford University first because Pisces isn't likely to fund Phase IV without Stanford's involvement. Kathryn also suggested we may want to talk to Dr. Matt Browning at Clemson University. He has been pushing for similar kinds of assessment in the epidemiology world.

Recommendations

In summary, we recommend our collaborator at the University of Wisconsin be the primary investigator of Phase IV. Dr. Amanda Siebert-Evenstone, who earned her Ph.D. Educational Psychology with a focus in Learning Sciences and a Master's in Environment and Resources, is in an ideal position at the University of Wisconsin to lead the Phase IV investigation and is prepared to seek funding support for the research. Dr. Siebert-Evenstone was one of the original designers of iPlan/LEM, now works in the Nelson Institute for Environmental Studies, and is in close proximity to the software developers, the Epistemic Analytics Lab. The collaborative value that this opportunity presents makes this the most feasible and productive scenario.

The following individuals should be contacted in the early stages of planning for Phase IV to determine their interest and level of participation:

Rupu Gupta, Knology

Dr. Marc Stern, University of Virginia

Dr. Bob Powell, Clemson University

Dr. Kathryn Stevenson, North Carolina State University

Potential Funding Sources

National Science Foundation NOAA Environmental Literacy Grant Program Burroughs-Wellcome Fund William T Grant Foundation Spencer Foundation Pisces Foundation

7. Develop a work plan for writing and submitting a proposal(s).

As mentioned above, our suggestion is for the Phase IV of the RI-AEL project to be led by the University of Wisconsin's Nelson Institute for Environmental Studies, specifically Dr. Amanda Siebert-Evenstone. We envision the essential, key partners of the project be Mass Audubon who will provide project management and consultation services, and RIEEA to contribute their strong relationships with the Rhode Island Department of Education and classroom teachers throughout the state.

We propose initiating the Phase IV effort in March 2021 via a virtual meeting with key personnel from Mass Audubon, RIEEA, and the University of Wisconsin (SERC, LLC). In this meeting, we will collaboratively develop a work plan for the proposal development and writing process. This meeting will yield an outline of objectives, proposed partners, funders, and the establishment of a project management plan. Of primary importance is to determine the grant programs to which we will be applying and the due dates for those proposals. This will assist in establishing the timeline for all other aspects of the proposal writing process.

8. Pilot the iPlan/LEM as part of RIEEA's Youth Leadership Retreat.

Unfortunately, we were not able to meet this objective. The COVID-19 pandemic that began within three months of the initiation of this project severely impacted the ability to coordinate a youth retreat. Further, it took several months for school systems to adjust to remote and hybrid learning. In lieu of a participating in RIEEA's Youth Leadership Retreat, we opted to conduct the three focus groups with students described starting on page 8.

Phase III Conclusions and Recommendations

Based on feedback from teachers, students, and environmental literacy experts, we conclude that iPlan/LEM should continue to be developed as an assessment of environmental literacy. Moving forward, we offer two sets of recommendations.

iPlan/LEM Modifications

The current version is easy to use, engaging, and enjoyable, however, the design team should add text entry options to foster student argumentation and reflection. Additionally, further studies should be conducted to understand the relationship between student problem-solving and actions within the tool. Based on these studies, the design and research teams should modify navigation, prompts, or other functionality to foster student problem-solving and environmental literacy.

Validation Studies

In order to ensure that iPlan/LEM is a valid and reliable assessment, we recommend the research team engage in validation studies. The research team would analyze how iPlan/LEM results compare with traditional validated assessments and interviews with students.

In conclusion, we recommend proceeding to Phase IV, which begins by writing grants to support iPlan/LEM modifications and validation studies. Mass Audubon plans to convene a meeting with RIEEA and Dr. Amanda Siebert-Evenstone in mid-March 2021 to initiate the process.