

The Climate Literacy and Energy Awareness Network (CLEAN)

Summative External Evaluation Report

Inverness Research, Inc.
February 2014

TABLE OF CONTENTS

I.	Introduction to the CLEAN Pathways Project.....	Page 1
II.	Inverness Research Role and Work	Page 2
III.	Report Findings.....	Page 4
	A. THE DEVELOPMENT OF THE CLEAN COLLECTION.....	Page 5
	B. NEED, ACCESS AND USE.....	Page 7
	C. QUALITY AND VALUE OF THE CLEAN COLLECTION AND SUPPORTS.....	Page 20
	D. IMPACT OF THE CLEAN COLLECTION AND SUPPORTS	Page 30
	E. THE LANDSCAPE OF CLIMATE SCIENCE AND ENERGY AWARENESS EDUCATION.....	Page 37
IV.	Lessons Learned for Future Investment	Page 48
	APPENDIX A: Selection of the CLEAN Informant Pool – September 14, 2010	Page A-i

The Climate Literacy and Energy Awareness Network (CLEAN)

Summative External Evaluation Report

I. Introduction to the CLEAN Pathways Project

Funded by the National Science Foundation, the Climate Literacy and Education Awareness Network (CLEAN) Pathways Project is a partnership among experts at TERC, the National Oceanic and Atmospheric Administration (NOAA), the Cooperative Institute for Research in Environmental Sciences (CIRES), the National Renewable Energy Laboratory (NREL), and the Science Education Resource Center at Carlton College (SERC). The project has created and pursued a process whereby online resources for teaching about the climate are identified, vetted, and curated on a website, and linked to AAAS' Benchmarks for Science Literacy and the former National Science Education Standards. CLEAN also created pages on the website specifically to assist educators in their planning for and teaching about climate and energy, supported professional development around the use of the collection, and become the home of the Climate Literacy Network (CLN, now CLEAN Network). While the CLN was active prior to CLEAN, the work of the Pathways Project helped expand and connect a larger virtual community, and is now part of CLEAN. The story of the development of this national educational community has also been well documented by the project leadership.¹

Over three years (2010-2013), CLEAN developed, refined, and implemented a rigorous process by which national experts in education and climate and/or energy science were convened to collect and review teaching resources. This process has been documented extensively by the CLEAN team,² and has resulted in over 580 high quality resources available on the CLEAN website (www.cleannet.org). In addition to the instructional resources, CLEAN also provides guidelines and principles for teaching about the climate and energy, and opportunities to participate in CLEAN community activities.

We view the project's work and contributions as a synergistic relationship among three key elements: professional community of leading climate and energy educators (including resource developers); vetted, high quality resources; and learning opportunities and professional supports. The diagram below provides an illustration of the relationship among them:

¹ Ledley, T. S., Gold, A., Niepold, F., McCaffrey, M., Sullivan, S. B., Manduca, C. A., Fox, S. (2013) *Moving Toward Collective Impact in Climate Change Literacy – The Climate Literacy And Energy Awareness Network (CLEAN)*. Unpublished manuscript.

² Gold, A. U., Ledley, T. S., Buhr, S. M., Fox, S., McCaffrey, M., Niepold, F., Manduca, C. A., and Lynds S. E. (2012). Peer-review of digital educational resources – a rigorous review process developed by the Climate Literacy and Energy Awareness Network (CLEAN). *Journal of Geoscience Education*, 60, 295-308.



II. Inverness Research Role and Work

Inverness Research, Inc. served as the external evaluator for the CLEAN Pathways Project from 2010 to 2013. The central focus of our evaluation was to assist the project in understanding their target audience’s contexts, needs, and interests with respect to teaching about the climate and energy, as well as their reaction to the developing CLEAN collection and website. In addition, we followed the project’s progress and conducted interviews with the target audience (2011), external experts (2013), and CLEAN leadership team members (2013). We stayed in close touch with the internal evaluator who monitored, documented, and assessed most project activities (i.e. the review camps, advisory board meetings, professional development events, and web-statistics).

Our main vehicle for data collection for the evaluation was an “informant group” consisting of a random sample of about 200 educators (grade 6 – 16) from across the United States who have at least some responsibilities vis-à-vis climate and/or energy instruction. The process by which we recruited this group, its general characteristics, and survey instruments are described in Appendix A.

The table below summarizes the size of the informant group and return rate for each survey:

Survey	Number invited	Number Returned	% return
Application Form	unknown	327 completed	unknown
Survey #1	220	213	97%
Survey #2	213	191	90%
Survey #3	193	152	79%

This informant group was surveyed on an annual basis to assess their interest in, concerns about, knowledge of, and needs and practices related to climate literacy and energy awareness, as well as their impressions of the quality and value of the growing CLEAN collection and the navigability of the website. The focus of the surveys shifted over time to reflect questions the CLEAN Pathways project had about their work or the status of the field. Informants were paid a total of \$225 over the three surveys, with some additional incentives to increase the return rate.

The two main research questions the informant group helped answer are:

1. What is the nature of the knowledge, beliefs, and practices of CLEAN’s target audience (instructors that teach about the climate and energy)?
2. What does CLEAN’s target audience think of the resources and support that CLEAN assembles (their quality, value, utility, etc.)?

After each survey, results were analyzed and summary reports submitted. In several cases, sub-analyses of particular questions were performed and reported. In addition, a small subset of the informants was interviewed (drawing from middle school, high school, and college-level informants) over the telephone about halfway through the project cycle to gather more detailed feedback about the CLEAN collection’s utility and value.

A note about definitions: For our evaluation, we drew on the expertise of the CLEAN project leaders to define the terms *climate science* and *energy awareness* for our surveys and interviews:

Climate Science: The study through observations, theories and modeling of the complex interactions of the atmosphere, lithosphere, hydrosphere, cryosphere, biosphere and human activities on the Earth’s climate system.

Energy Awareness: Understanding the complex physical, technical, social and environmental context of energy in our lives, and being able to make informed, evidence-based decisions from this understanding.

In our data-gathering instruments we separate climate and energy as they are treated separately on the CLEAN website, each with distinct essential principles and rationales for inclusion in the curriculum. The CLEAN leaders were interested in finding out if informants had different perspectives on teaching climate and energy, and if they experienced different kinds of affordances and constraints with respect to teaching these two topics.

Other sources of data **for this report** include:

- Numerous meetings and calls with the CLEAN leadership and evaluation team
- In-depth interviews with external experts (6) in 2013
- Summative interviews with project leaders (8) in 2013
- Selected internal evaluation reports and findings

This report highlights the key findings of our evaluation work over the three years with an emphasis on the informant group data and interviews, as well as findings of the internal evaluation where appropriate. We conclude with a summary of lessons learned and implications from the CLEAN pathways project.

III. Report Findings

This main section includes findings related to the following areas:

- The Development of the CLEAN Collection
- The CLEAN Collection: Need, Access And Use
- Quality and Value of the CLEAN Collection and CLEAN Professional Development Activities
- Impact of the CLEAN Collection
- The Landscape of Climate Science and Energy Awareness Education

In terms of the informant group data, we draw mostly from the first survey for many sections of this report unless there were changes over time, or we are presenting new data from the second or third survey.

A note about the context for our informant group findings

We report our findings regarding our informants' knowledge and beliefs in some detail, but it is important to note at the outset that most informants at all levels say that climate change and energy awareness are of great importance to them personally.

The people in this pool may be atypical of all educators in that they are very active in professional and other activities outside of their classrooms related to climate and energy, and therefore perhaps more knowledgeable than average about the needs of the field.

Additionally, there are a number of differences across grade levels in terms of their needs and interest.

Note also that the situation of those teaching “climate science” and those teaching “energy awareness” seems to be somewhat different, in that those teaching climate science appear to have more colleagues, support, resources, etc. than those teaching energy awareness.

Awareness of these differences may help inform design choices for the collection, as well as for future professional development and social networking efforts.

A. THE DEVELOPMENT OF THE CLEAN COLLECTION

Besides the collection of resources and website, an important outcome of the CLEAN project is the process and criteria developed for identifying and reviewing resources for ensuring that only those of the highest quality are included in the CLEAN collection. The project leadership has written extensively about this process in a paper published in 2012.³ The fact that the resources have been so rigorously vetted is important to users, particularly those teaching in higher education. Over time the project leadership learned how to streamline and improve the process, and the last two review events have taken place virtually to save time and money.

The resource review process itself was a professional development experience for the CLEAN leadership and review participants. CLEAN leaders reflected on the challenges of the process in summative interviews, and overall, the respondents said that the review process – while demanding, expensive and difficult – was worth the effort because of the high-quality and rigorous criteria imposed on the resources. They felt that the review process was valuable for the people who participated; at least one wanted more classroom teachers involved. They felt that the group could be a model for others wanting to conduct a similar project.

The reviewing process has been a model, and no one had actually managed to pull off a review at this scale before of online teaching resources at least inside this kind of budget or in the realm that I operate in.
– Project Leader

I was quite impressed with my small participation. I could see how that would generate high quality resources... even that little part was a small microcosm...
– External Expert

Everybody always underestimates how hard it is going to be to review something, and it was honestly like we thought – “this should be an easy task, figure out which is good, which is bad, you set up a rubric and evaluate it.” I think a lot was learned about how hard that is in detail and how specific it is to an audience group ...the higher the bar

³ Gold, A. U., Ledley, T. S., Buhr, S. M., Fox, S., McCaffrey, M. Niepold, F., Manduca, C. A., and Lynds, S. E. (2012). Peer-review of digital educational resources – a rigorous review process developed by the Climate Literacy and Energy Awareness Network (CLEAN). *Journal of Geoscience Education*, 60, 295-308.

you set, the more redundant and rigorous the review process has to be to be, not even to be fair, just to be consistent.

– Project Leader

I feel like the amount of time put into each resource is huge. I hope that people funding this and who get CLEAN understand the value that has gone into that, and the amount of expertise and the amount of eyes and the amount of different points of views that have looked at each one of those resources.

– Project Leader

The reviews obviously are very thorough and arguably maybe too thorough, because so many hands, many people had to look at each artifact before it got approved and annotated and so it ends up being pretty expensive when you consider it is just 500 resources or whatever it is. But on the other hand, it really does cover most of the climate and energy literacy key concepts and obviously not all of the concepts are equally important and so I think there is in general a good representation of the most important resources or the most important principles and concepts.

– Project Leader

It has taken a lot of time to develop the shared understanding of what we mean by our review criteria and so for both of our resource collectors and our community of reviewers, it has taken a lot of training, a lot of testing.... We did ... a lot of training around understanding the variability and reviews and making sure that our reviewing committee and our resource collectors had a good shared understanding of what we were looking for – that takes time to develop.

– Project Leader

It is a lot of elbow grease and I know it is an arduous and rigorous process, but on the other hand, I think as a result we separate the wheat from the chaff and we have a very high-quality product that is rock solid and exactly the right platform to stand on for the next phase.

– External Expert

In interviews with project leaders toward the end of the project, most reflected that while the collection is perhaps the most important outcome of the project, the review process and criteria are also a critical and highly “leveragable” outcome for the field, and for future iterations of a resource collection like this one. One project leader noted:

From a teacher’s perspective, I do think that the collection is the most important outcome. But if you look from the developer side, I think that the review criteria are the most important and I do think that for professionals like curriculum developers and people who are just working climate change education in general, maybe the community that has been built around CLEAN, and highlighting the different projects and trying to figure out who is working on each project, is the most important.

Finally, in addition to the reviews that took place for the collection, there was also an effort to identify those topic areas where there are very few quality resources available online, which led to a document that is hoped will guide curriculum developers in the future. A PI explained:

We bought into the myth that is out there that we don't need to develop curriculum because there is already tons and tons of good stuff out there. But what we found as we dug into it with our review criteria was that in fact, there is tons of stuff around certain topics, but not across the entire conceptual framework as described by the literacy principles. So there is a gazillion resources about tree rings, but not about many of the other concepts and so that is why the 'gaps and thin spots' product is useful because it can help inform decisions about what is actually needed from developers and from funding agencies and what not.

Ultimately, the criteria that were developed and the process for review and annotation of each potential resource is a significant outcome of the CLEAN project, and has the potential to influence future efforts like it. The project has already written and published a paper comparing their process to other documented processes, and they have presented on their work at numerous conferences and meetings with the goal of helping to increase capacity across the field.

B. NEED, ACCESS AND USE

In this section, we present findings from the informant survey and interviews with informants and field experts about the perceived need for high quality resources and supports, the extent of access instructors have to resources and supports (including the CLEAN collection), and their extent of use of resources.

To what extent is this CLEAN collection needed among target audiences?

In this section, we draw from our data sources to highlight areas of need, which the CLEAN collection and supports could address. These areas are: knowledge and beliefs; teaching practice; student interest; professional development; and collaboration.

Need related to educators' knowledge and beliefs

Our informants do not need to be convinced of the reality of climate change: 93% agree that it is happening.

In our exploration of the group's knowledge and beliefs as measured by a small set of Six Americas questions,⁴ we found that middle school informants are less knowledgeable in some areas than other informants. Our results also suggested that there are important gaps in knowledge that CLEAN resources can help fill. For example, 43% of middle school informants did not know the correct answer to the question "*On average, how long does carbon dioxide stay in the atmosphere once it has been emitted?*" (Six Americas Question 23 in 2010).

⁴ <http://environment.yale.edu/climate-communication/>

Need related to teaching practice

On our first survey, most informants said that resources were available for teaching about climate and energy. At the upper division level, more say resources are *very* available for teaching about the climate and that resources for teaching about energy are *less* available.

Most informants perceived available resources to be of good – but not excellent – quality. There was slightly less agreement on their value, though most said they are of considerable to great value.

There seems to be a strong need for materials that are designed to meet student interests, that reflect the instructional preferences of the teachers, and/or that meet the needs of students with remedial science and math skills. This is true across all grade levels.

In interviews, the informants agreed resoundingly that there is a need for the kinds of teaching materials CLEAN includes, particularly materials that help students understand basic concepts related to climate and energy. A majority would use more hands-on, active learning materials if they were available. One of the surprises of the interviews was that post-secondary educators voiced this need more strongly than secondary teachers. Similarly, they welcomed more technology-based resources such as simulations, etc.

As might be expected, some secondary teachers are somewhat constrained by standards, by their perceptions of what their students can understand, or by a belief about the appropriateness of introducing controversy (i.e., climate change as a controversial topic). However, overall, the surveys and interviews portrayed a group of educators who believe they have considerable professional autonomy to teach climate science and energy awareness topics as they choose and are likely to welcome inclusion of resources covering a broad array of topics, and representing a range of opinions, experiences and perspectives. At the same time, while they include teaching about misconceptions and controversy in their courses, they are most strongly committed to laying a solid foundation in “the science” underlying climate change. Some representative comments from these informants are below:

[These resources are] definitely [needed], because a lot of my students have no idea what is going on with the climate. I'm working on my dissertation and that's part of my topic...developing an environmental ethic in them.

[These resources are needed] because there isn't a textbook or an obvious set of learning objectives.

People look to the web for teaching ideas and their time is limited and they can find some very solid concepts quickly on this website. These key concepts fit into what teachers need and then backing them up with good activities is really good.

When asked in interviews what they might do differently in their teaching if different kinds of high quality resources about climate and energy were available to them, most

interviewees stated that they would like to do more “hands-on,” “active” learning activities with their students. This was particularly true for the higher education instructors. Some others also noted they would like to do more with real data and tools, provide more opportunities for their students to do their own research, or participate in a conference where students could meet scientists. One would rely on online resources exclusively because these resources are more relevant than textbooks. Some noted that they would like to teach more about the political dimensions of climate change.

Finally, the design of the CLEAN project – combing the internet for existing resources – limited the work to what was “out there,” versus learning about the needs of educators and addressing them directly, as one PI stated:

Because we were simply drawing on what existed rather than trying to take a look at what was needed, I think because of that pre-condition, the resulting collection is not necessarily going to be perfectly aligned with what everybody needs, because a lot of things that people need don't exist or aren't findable in this way. I think that is a design challenge that was implicit in the proposal...

Need related to perception of student interests

Secondary level instructors perceive their students are most interested in alternative energy, human impacts on the environment and climate change in general; university instructors perceive their students are most interested in human-based climate change, alternative energy, human impacts and solutions to climate change. Perceived interest in energy conservation, regional impacts and general climate science decline over the grades, while perceived interest in human-caused climate change, solutions, and sustainability increases across the grades.

These results suggest that students are tuned to the issue first, and the science second, hence the doorway into student interests appears to be the presentation of compelling issues and problems, coming to understand those problems through the science, and then thinking about solutions with a science and society lens. Therefore, materials that highlight and lead with issues and problems may be quite useful.

In terms of instructional modes, informants perceive students are most interested in hands-on lab activities – by a wide margin – compared to other instructional approaches. Informants report that more advanced students are less interested than younger students in hands-on activities, using real scientific technology, fieldwork, producing creative work, service learning and citizen science projects. Conversely, interest in viewing documentaries and reading popular articles rises as students progress through the grades. It is interesting to note that instructional approaches do not track very closely with student interests.

Need related to professional development (needs of providers)

Sixty-seven members of the informant group had provided professional development in climate science, energy awareness or both (30% of the middle school educators, 32% of the high school educators, 42% of lower division university instructors, and 53% of upper division university instructors) by 2011. Informants who provide professional development for other teachers were asked to name challenges they have experienced providing professional development in climate and/or energy:

- Close to 25% of respondents said that time was the biggest challenge: time to plan, time to prepare, lack of time to go in-depth, teachers' limited time to attend, etc.
- About 20% reported that finding information, resources, lessons, activities and teaching materials were the biggest challenges.
- Money was mentioned third with just over 10% of respondents saying that lack of funding was an issue.
- Ten percent said getting teachers to participate was a challenge.
- Several responded that dealing with skeptics is a challenge.
- Several said that providing hands-on activities is a challenge.

This speaks not only to the level of knowledge of professional development of the informant group but also to the possible need for quality materials that would be suitable for a professional development setting.

Need related to collaboration

Seventy-two percent collaborate with colleagues in climate science and/or energy awareness – mostly in both subjects (39%) or in climate science only (27%). Only 6% (all but one at the secondary level) collaborate only around energy awareness.

Most collaborate in climate science to develop curriculum or develop content knowledge (their own or others). At the secondary level informants often plan course scope and sequence together, while at the postsecondary level they conduct educational outreach and research. Figures for energy awareness are roughly comparable for the most common purposes. At the postsecondary level, informants do less energy outreach and research, and more planning of course scope and sequence.

Most believe that their colleagues see them as resources in climate science to at least some extent – and about 2 or 3 in 10 say they are resources for others to a large extent. On the flip side, informants draw on the climate science expertise of their colleagues to a lesser extent. Upper division university informants report the most reciprocal relationships. As might be surmised from other results in this report, fewer informants say that they are resources to colleagues or draw on the expertise of colleagues in energy awareness (as opposed to climate science).

Experts and project leaders weigh in on the need for CLEAN

Experts in the fields of climate science and energy also believe that there is a strong need for quality teaching materials. Indeed, the CLEAN project was founded on the basic assumption that teachers need a way to filter and make judgments about the many online resources having to do with climate and energy education. The following quotes from interviews point to some specific needs as perceived by the external experts and project leaders:

At its essence, the CLEAN collection is a curated, peer reviewed collection of learning resources that are aligned with important concepts, as identified by the climate and energy science and education communities. So that means that if you contrast the experience of coming to CLEAN with the experience of looking for things out on Google, or in a gigantic collection, you don't have the kind of conceptual framework that allows you to put learning resources into a scope and sequence that makes sense. CLEAN helps with helping educators teach more conceptually as opposed to topically, or it can do that, the capability is there through the 'teaching about' pages, through the tagging and through the strand map, to help teachers make that transition.

– Project Leader

...[It] takes a dedicated teacher to go out there and teach something that is not in their curriculum and find ways to fit it in... CLEAN does a good job of having vetted resources in one place where they can get to them. I think those are essential principles that have been developed for earth science, atmosphere, oceans, climate change, energy – those help too.

– External Expert

I think that it is important not only for pre-college educators (who are rarely formally trained in these topics), but also for undergraduate faculty at the community college level, and for those who are teaching broad survey courses, because in those situations, those faculty members have also not had formal training in these topics usually.

– Project Leader

In summary, there is a need in the field for quality resources to use with a range of student grade levels, abilities, and interest, and that are trustworthy and easy to access. The field also needs resources that help professional developers. Finally, instructors are inclined to collaborate with others in their planning for instruction about the climate and energy, suggesting an ongoing role for the CLEAN community.

To what extent is the CLEAN collection accessible to target audiences?

After using the CLEAN website in 2011, nearly half of the informants (47%) agreed strongly that the organization of the content on the website was easy to follow. By March 2013, our informants were nearly unanimously satisfied with how easy it is to use the CLEAN website (99% agree or agree strongly that it is easy to use). Users tell us that the site is accessible on a number of specific dimensions: from its design, to its use as a link to related resources. Users reported that it is well designed (98% agree or agree strongly) and

easily searchable (93%). Beyond that, they said it is clearly designed for educators at the targeted teaching levels (98%) and the content and materials are at an appropriate level for their students (93%). Informants said it provides sufficient information for them to use teaching activities on the site (96%) and/or to help them generate new ways of teaching about climate and energy (97%). Almost all (93%) of informants have technology that will allow them to access and use these materials in their teaching. Finally, the vast majority (96%) of informants say that if users wanted additional information about a given climate or energy topic, the site provides relevant and easy-to-find links to additional resources.

It should be noted that roughly 2/3 of the informants who said they agreed or agreed strongly with these statements gave the slightly tempered – “agree” rating rather than “agree strongly.” While it is admirably accessible as it currently exists, there is still room for further refinement of the site along this dimension. In particular, secondary teachers give significantly higher ratings than our postsecondary informants to the site’s appropriateness for teachers at their own level and their students. More secondary teachers also believe that the content on the site could help them generate new ways of teaching about climate and energy.

In **interviews**, in 2011, a subsample of informants described their experiences searching for materials on the CLEAN website. Overall, their responses were mixed: just over half said that they were able to find the materials easily. Others couldn’t find an exact match for what they were looking for, felt the materials were not at the right level for their students, or found the click-through process too lengthy.

Interviewees made a number of specific suggestions to improve general usability of the site: require fewer clicks to get to resources/allow for general browsing, reduce the number of words on some pages, make it clear how to get back to CLEAN from resources, or make the link to a grade level more quickly. Several asked for more information (e.g., about the featured resource, blog writers or animals) or activities (in general, at a lower or higher level of difficulty). One post-secondary reviewer would like to see animations and simulations. There were several recommendations related to communications (“get the word out,” have the website be the top link on a Google search, etc.). Several post-secondary reviewers asked for resources to help refute doubters.

In interviews with experts and project leaders, access was perceived as more an issue of marketing, or making people aware that CLEAN exists, perhaps supplementing the site with a kind of users guide or “concierge”:

I do like that there [are] data and figures available that people can use. The fact that the reviews are quite transparent is nice. We have the teaching tips, the science, and then the pedagogy. There are certainly some comments in there that are warnings... from the reviewer. These are all useful.

– External Expert

Some people say, ‘oh my god, 500 resources, that is too many’ and then other people will say, ‘I am not finding what I am looking for.’ On some level, you can’t really win,

but [CLEAN is] so far superior to just having teachers scouring Google to find the little nugget that they are looking for to fill in their curriculum...

– Project Leader

To what extent and how is the collection being used?

On first review, informants said that they were likely to use the website for a multitude of purposes – to educate themselves, to share with other educators, and in their planning and teaching.

An investigation of actual usage. On the second survey we investigated the question of which information and resources are valuable to educators by giving the informants the option to search for any kind of resource or information. What did informants actually search for? Not surprisingly, it differed by grade level:

Middle School. Many middle school teachers searched for resources to help them teach a particular topic (energy/energy transformations, solar impact on climate, ocean acidification), and/or that aligned with the standards they are expected to teach. Several looked for more general resources, such as activities to help teach about global warming or topics that connect to students' lives. Some noted they were looking for lessons that utilized a particular pedagogical approach, such as lessons to use in small groups.

High School. As with the middle school informants, the high school teachers looked for resources related to a particular topic (e.g., energy budget, carbon dioxide, alternative energies, arctic sea ice, the Kyoto protocol). Some teachers looked for general resources for updating their current work, or visualizations and graphics to augment their lessons.

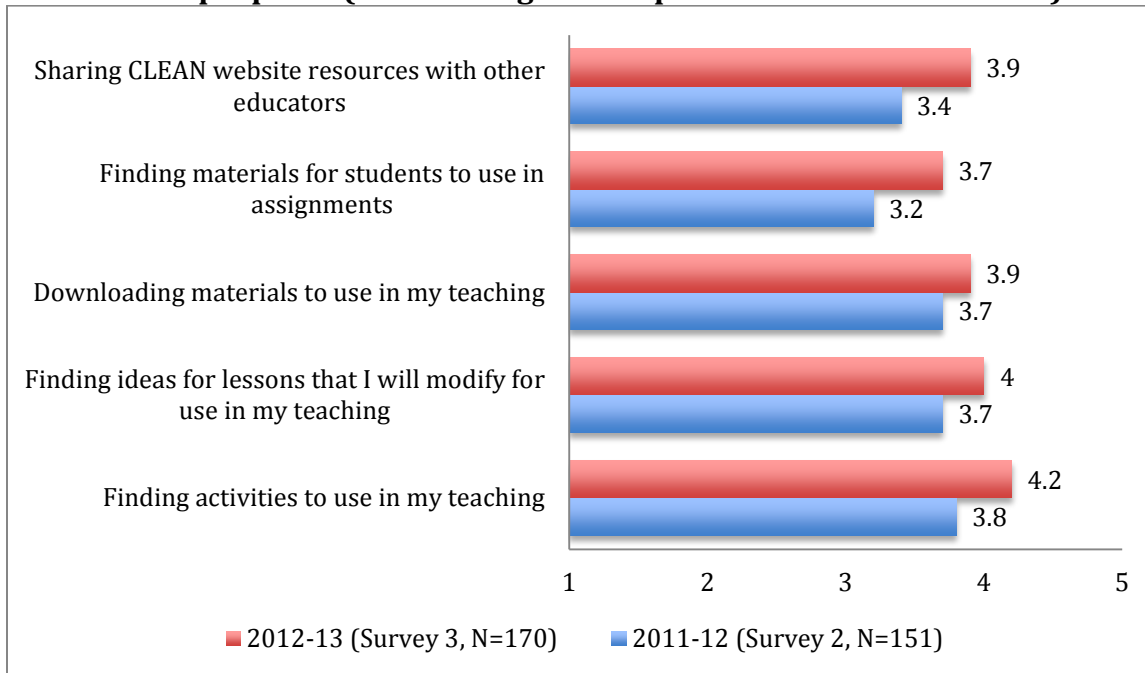
2-year college instructors, lower division undergraduate instructors, and upper division instructors looked for resources related to a topic, or specific to the subject of the courses they were teaching.

Though differences are not statistically significant, it appears that users at different levels search using somewhat different criteria (e.g., at the college level, there were fewer searches by grade level and more searches by resource type). Sixty-one percent of all searches were for activities. Videos were a distant second, accounting for 17% of the searches, followed by visualizations (11% of searches) and short demos/experiments (5%).

Over 90% of the informants have accessed the CLEAN website looking for teaching resources or activities (not including times they have accessed it for our study). Thirty-four percent have used it once or twice, 51% have used it 3-10 times, and 8% have accessed it more than 10 times. **Therefore, a key finding is that usage increased once people were asked to try it.**

Informants are using it for more purposes now than they were several years ago. When we compared survey data for 2012-13 with 2011-12 (Survey 2), we identified five purposes for which educators were significantly more likely to use the CLEAN website after they were more familiar with it:

Increase in likelihood that informants would use the CLEAN website for various purposes (mean ratings on a 5-point scale: 2011 and 2013)



1=Not likely, 2=Unlikely, 3=Likely, 4=Very likely, 5=Already used

Actual usage of the website in 2010-11 seems roughly in line with usage informants projected in their first survey. For example, 95% of the informants responding to Survey 1 said they were likely or very likely to download materials to use in their teaching in 2010-11; by January 2011, 75% had already used it or said they were likely to.

CLEAN is now a primary informational source on climate science for a majority of informants, with especially high usage at the middle school level.

Top five resources that informants turn to when they are learning about climate change on their own

	All respondents (N=148)	MS (N=21)	HS (N=49)	Lower Division (N=28)	Upper division (N=20)
Documentaries, special TV programs	66%	72%	80%	6%	50%
CLEAN website	63%	83%	61%	54%	50%
Professional journals	62%	48%	61%	64%	85%
Trusted internet sources	59%	52%	59%	54%	55%
Books, magazines	57%	55%	55%	46%	60%

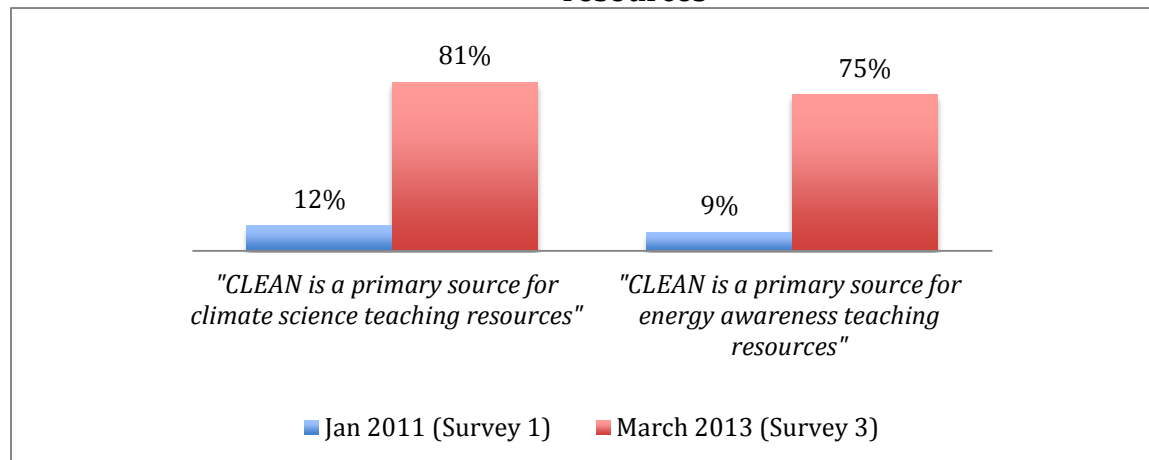
It is also one of the top three “go to” resources on energy awareness for users.

Top five resources that informants turn to when they are learning about energy awareness on their own

	All respondents (N=141)	MS (N=28)	HS (N=47)	Lower Division (N=28)	Upper division (N=16)
Trusted internet sources	62%	50%	68%	57%	63%
Documentaries, special TV programs	61%	64%	74%	39%	63%
CLEAN website	59%	71%	57%	54%	50%
Books, magazines	51%	39%	53%	50%	56%
Professional journals	50%	50%	47%	57%	56%

As our informants have become familiar with the CLEAN website and participated in our study, many more are now considering it a primary source for teaching resources as well. In 2012, 81% reported that it is a primary resource for teaching climate science – up from 12% in 2011. All grade levels reported a major jump. Similarly, the percentage who considered the website a primary resource for teaching energy awareness jumped from 7% to 75%. Ratings of other resources shifted little if at all over the two years.

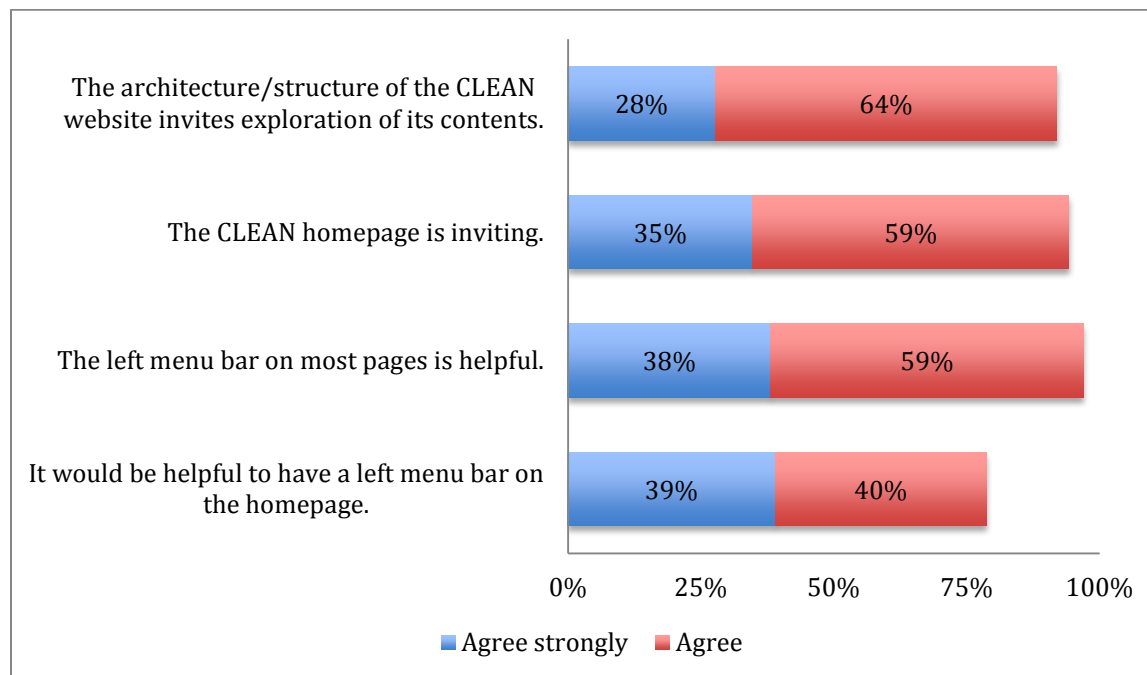
% of informants who consider the CLEAN website a primary source for teaching resources



Issues with site appearance, navigation, and use

Some sections of the website were considerably easier than others for the informants to find. The Essential Principles, Collection of Educational Resources, and search features were easiest to find, followed by information on how to teach Climate and Energy Topics and Challenges in Teaching Climate and Energy Topics. At least half of all respondents found these sections very easy to find and most of the rest said it was fairly easy to find them. Relatively few (20%) said it was very easy to find how to submit materials for review.

In 2013 we asked a few specific questions on the survey about site navigation that the leadership team was interested in finding out about, specifically the extent to which the group found the landing page to be inviting (94%), the extent to which the structure of the site invited exploration (92%), and whether or not the left menu bar was helpful (97%). As the graph below illustrates, once again judgments were positive, but indicate further refinement might improve the user experience.



Rating scale: 1=Disagree strongly, 2=Disagree, 3=Agree, 4=Agree strongly

When asked to comment on anything about the website that was difficult to use, informants made the greatest number of comments and suggestions with regard to the homepage and the overall design of the website.

On the 3rd and final survey, several people commented on the improvements made to the home page since the second survey. Others thought it was still too heavy on text and/or uninviting. As one reviewer said, *“it gives information overload with simplistic graphics.”* Another noted, *“The page does NOT say enough about what it is and its potential to educators; it does not draw in a person unlike for instance the SERC website.”* Several people

noticed that there were no very recent updates, and some found it hard to figure out where to go next once they landed on the home page.

Comments about the design ranged from opinions that fonts were too small or should be different for different elements, to more substantial comments that the design does not convey the depth of resources or make it simple enough to search the site:

The resources are the most valuable part to me. I would like to see it made more obvious that there are all these resources when you first enter the site. I know they are there because I have explored it for this study. However, a casual user may not immediately realize the wealth of resources available unless they do this, too.

Perhaps have a code to identify the type of activity (hands on, computer, case study, etc.) as well as the general grade levels - when you click into the list from the Teaching Climate Literacy subtopic, there isn't any quick way to eliminate unlikely candidates. There are many very good ones though, and I like having this topical option in addition to the more detailed/refined search.

I have had trouble finding a resource again that I once used on the site. This is because there are so many resources on a given topic that older resources appear to get buried in the back. It can be difficult to sift through everything to find the resource I'm looking for.

A few could not find resources of a particular kind, such as video clips, more advanced materials, and online interactives. We shared all comments and suggestions with the project team to help guide further development of the site.

Interviews with experts and project leaders revealed there is some concern that at least at the time of the interviews, it did not appear that the site is getting as much use as hoped. However, recent web statistics show a small but steady increase in the actual use of the site, and an increase in unique users. All agreed that it takes time to build an audience and that most of the project's resources were earmarked for creating the collection. Sample comments about this include:

I don't think the site has enough use and I don't think that is a failing. I think that probably reflects that it is going to take some time to build that. CLEAN is sitting by itself as a stand-alone site and you can get to it through the SERC collections, but it is not capitalizing on that URL.... I think the NOAA strategy, becoming part of NOAA, which I think people are going to for climate resources, is probably a really strong strategy for building use.⁵
– Project Leader

⁵ At the time of this writing, CLEAN has achieved a partnership with NOAA such that CLEAN is currently syndicated to climate.gov. That is, the CLEAN Teaching and Resource pages are the official NOAA education resource content.

If you have lost your funding from NSF and you now are on life support, the thing that is going to improve your ability to sustain yourself is to show outcome. If you can say, "now we are dramatically and substantially growing the number of classrooms and free choice learning institutions that are using our resources," that gets me to sit up and take notice. I will feel much more inclined to invest in it, if I know that you are achieving that outcome, as opposed to saying, "well, we need more money to do a gap analysis and so we can get more than 510 resources to cover more topics." That is not a selling point to me. I want it used and I want it used today.

– External Expert

I can't imagine anything more important than channeling energy into getting this used in classrooms and in free choice learning venues now as much as possible. I hope people do share that because I know that there are other priorities and there are other things that are important to do, but I don't think any is as important as that.

– External Expert

A PI noted that the look and feel of the site has been challenging to get right, particularly when trying to serve multiple audiences:

Our challenges have to do with having our product meet educators' expectations of being easy to use and engaging, when they first come. If you compare how we talk about ourselves and how it looks when you come to CLEAN versus other educator platforms, it is clear that we are not as adept at describing ourselves and building something that a teacher then wants to dive into. Once they get into it, they like it. But it is a little daunting to people who come to see all of the text. We have been working on that, but it has been a challenge to figure out how to prioritize and how to move ahead with the resources that we have. And also challenges that we have two different audiences stated and we have undergraduate educators and faculty at the higher ed level and there is a concern that we not do something for one audience that turns off the other audience.

Cleanet.org Web Statistics

In terms of the numbers of people accessing the site, the internal evaluator gathered monthly and quarterly web statistics reflecting activity on the CLEAN website from February 2011 through today. Here we share a few highlights of notable changes in new and unique visitors over the last two years (January 2012 through the present). According to Google, a new user is one who comes to the site for the first time, regardless of time frame, and a unique visitor is one who is counted once during a time frame regardless of how many times he/she visits the site. New users are a subset of unique visitors.

New Users Observations

Overall, new user visits increased 55% in 2013 over 2012, from 42,778 to 66,284. Other interesting information about new users includes:

- Tablet usage is up 177%, and mobile phone usage up 200%.
- At the same time, desktop usage is up 46%.
- International usage, in particular from India, UK, Australia, Germany, Pakistan, and South Africa increased by over 100% this year.
- More new users accessed the “Energy Quiz,” with direct links up by 255%. The Energy Quiz is the second-most popular entrance after the home page.

Unique Visitors

Unique visits to the website in 2013 were also up 55% over 2012, from 43,400 to 67,076. Pages per visit dropped nominally as did average visit duration. The number one referral source for CLEAN is the Department of Energy (energy.gov), followed by the Alliance for Climate Education (acespace.org) and NOAA (Climate.gov). In general the site experiences reduced traffic in the summer months and in December.

Summary of Need, Access, and Use

Informants, experts and project PIs indicated specific needs related to: audience knowledge of climate and energy concepts; teaching practice – particularly hands-on, issue- or problem-based materials and resources for students with weak math skills; information, lessons and activities for professional development providers; and a small but growing community of collaborators.

Informants found cleanet.org quite manageable and ease to use, but there is room for improvement, particularly with respect to the amount of text on some pages and the number of clicks needed to find what they were looking for.

What they look for and why varies by grade level, but most are interested in activities, videos, visualizations and short demonstrations. Importantly, once introduced to the website, usage increased. CLEAN is now among the top five sources the informant group turns to when searching for a teaching resource.

A large majority of informants found the general structure/architecture, homepage, and location of menu tabs helpful. Suggestions for improvement were directed at improving the look and feel of the homepage, and better search options for ease of use.

There is some concern among the PIs and field experts that usage is low, and that there hasn’t been enough effort put into increasing use.

Finally, while we don’t have information about who is coming to the site, web statistics indicate that overall visits are increasing for both new and unique visitors.

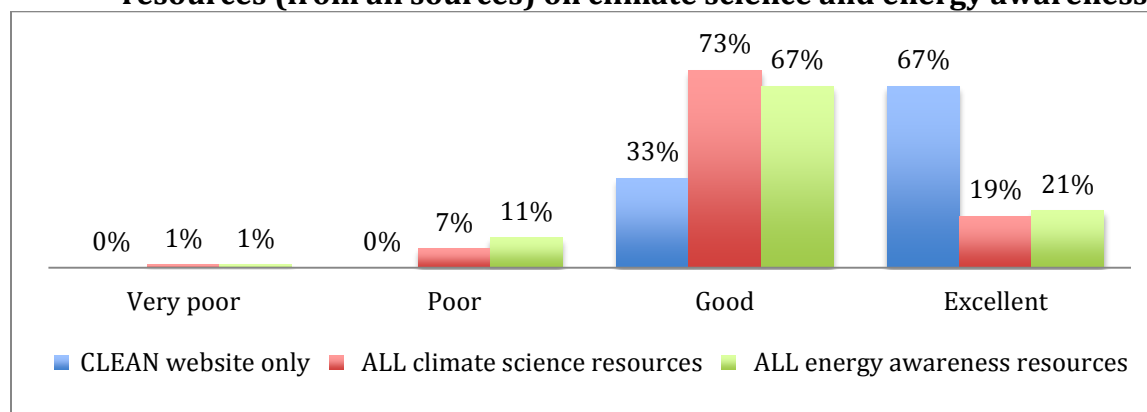
C. QUALITY AND VALUE OF THE CLEAN COLLECTION AND SUPPORTS

What is the perceived quality of the CLEAN collection as a whole?

When respondents were asked about their initial impressions of the CLEAN website on our first survey, the overall ratings of the website and collection were positive, but they were not outstanding. Ratings of the website use experience were significantly higher *after* informants used the site in preparation for taking the second survey. The percentage who agreed strongly with positive statements about using the website was almost double from Survey 1 to Survey 2. This suggests a key priority should be getting educators to TRY the site.

By the third survey informants unanimously rated the quality of the CLEAN website overall as good or excellent – considerably higher than they rated all resources on climate science and energy awareness on the same survey. Nearly three times as many informants rated the CLEAN website overall as “excellent” compared to their ratings for climate science and energy awareness teaching resources overall.

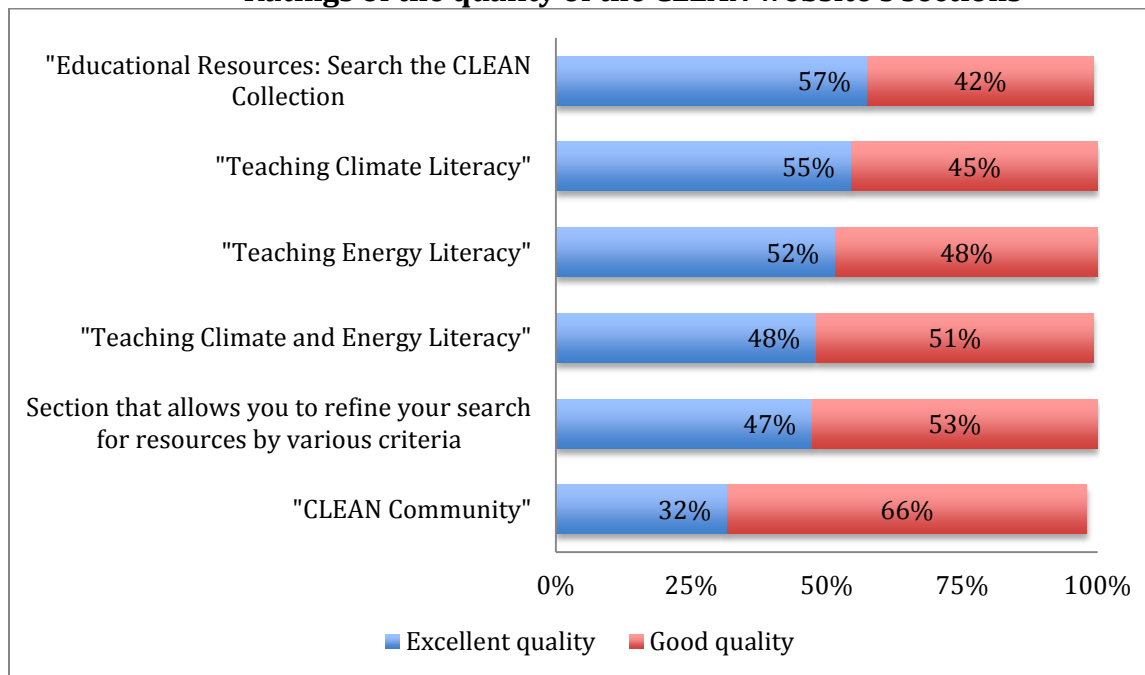
2013 ratings of the quality of the CLEAN website overall compared to ratings for all resources (from all sources) on climate science and energy awareness



In interviews, informants rated the resources they found on the websites as very high quality. Their reasons for the high ratings included: the use of real data; sound/reliable/trustworthy science presented from an educator’s perspective; completeness of the collection; and inclusion of resources not available elsewhere.

On the third survey (2013) we asked informants to rate the quality of the various sections of the CLEAN website. All but a few people rated every section as being of very good or excellent quality. There is a fairly even split in “good” and “excellent” ratings for most sections, but ratings are especially high for “Educational Resources: Search the CLEAN Collection” while ratings for the “CLEAN community” section are lower than others (but still positive).

Ratings of the quality of the CLEAN website's sections



Field experts also commented in interviews on the quality of the CLEAN collection:

The quality of the organization [of the collection] is really strong and the quality of the individual contribution is really strong. From the looking at it that I have done, it is really pretty good breadth.... I liked the fact that it is organized into different grade levels, different climate principles, and those kinds of things – the organization is actually really helpful. ... [I would rate on scale of 1-5] 5. There's no question in my mind; this is my go-to source.

I think the collection itself and then having it sortable and siftable by grades and by topics...is good and having the meta-data and having had it so rigorously reviewed and documented as to its soundness and accuracy and having that endorsement at a high level. I think all of those things gives it that stamp of approval that I as an educator would feel much more comfortable than just say grabbing some random thing off the internet and bringing it into my class and wondering ... is this accurate?

The review process, the diversity of the backgrounds of reviewers is a strength, a different perspective... gives advice from different angles...I like that it is all sorted in different ways so you can target the year, level and the subject matter... and then this is a bit of my own perspective, I like that they are addressing the misconceptions and starting to use the psychology of the misinformation to structure the lessons and hopefully reduce misconceptions...

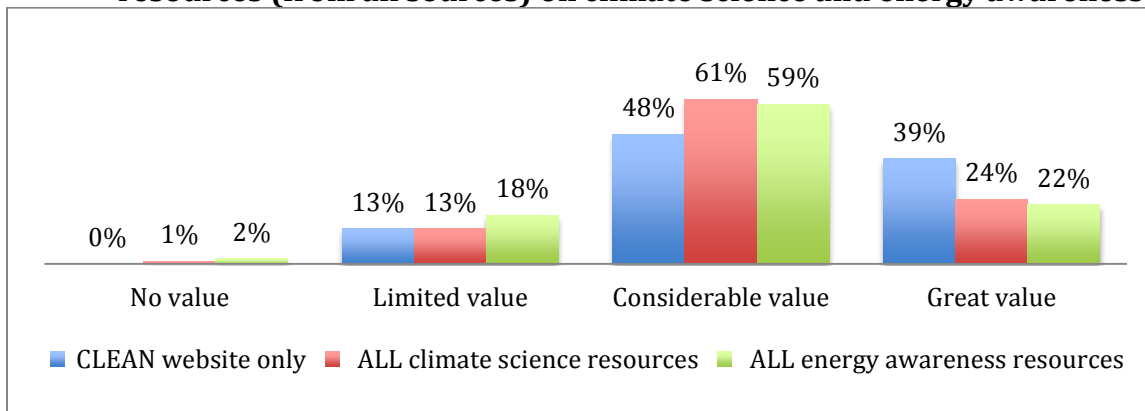
Attributes that expert interviewees cited as contributing to the quality of the site include:

- Credibility and reliability of resources as a result of rigorous review process
- Ability to sort and search by subject matter and grade level
- Being able to see reviewer comments
- Having a platform for collaboration
- Having professional development based on and supportive of the collection
- Learning on the part of staff and developers about what is considered strong science and strong pedagogy
- Having users/audiences included in review process

To what extent do users value the collection?

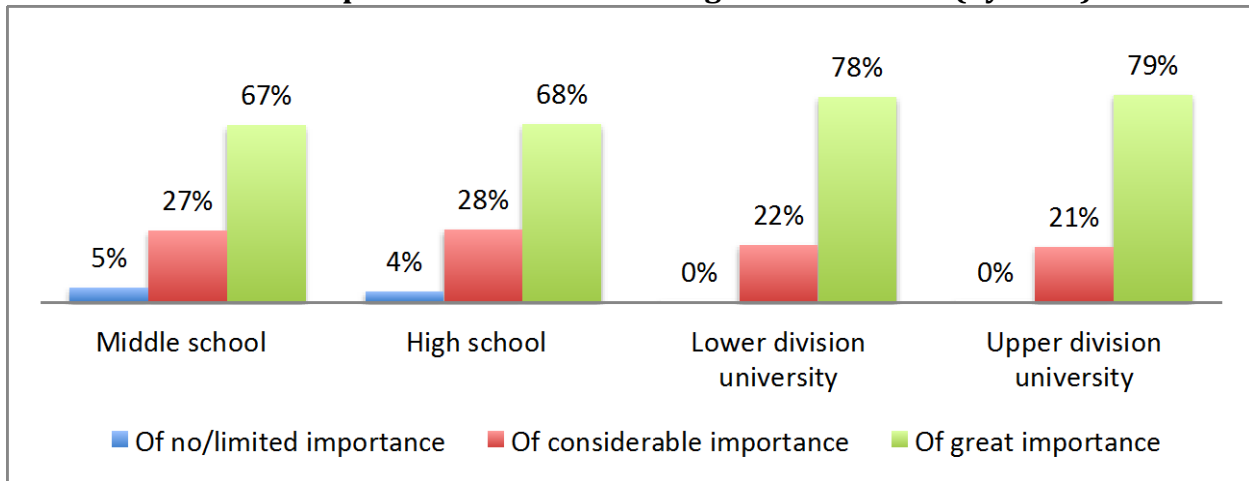
On the third survey, a large majority of the informants said that the collection was of considerable or great value to them. As was the case for ratings of the quality of the website compared to the quality of all resources in climate science/energy awareness, the informants rated the website higher than other resources.

2013 ratings of the value of the CLEAN website overall compared to rating for all resources (from all sources) on climate science and energy awareness

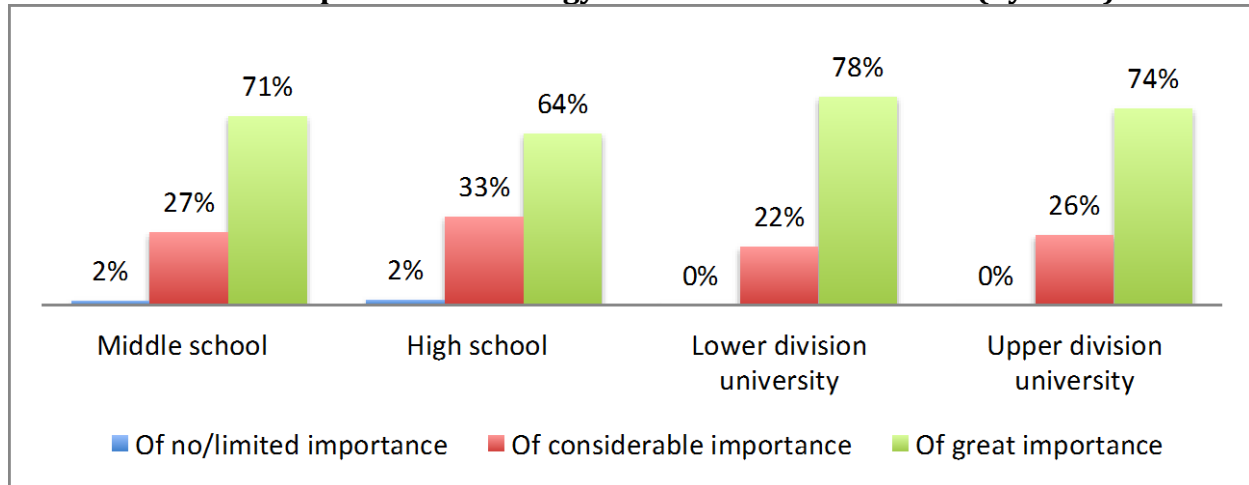


Informants value the collection both because they care about the issues and topics it addresses and because it contributes to their instruction. In their view, the collection addresses topics and issues of personal interest to the great majority of our user group.

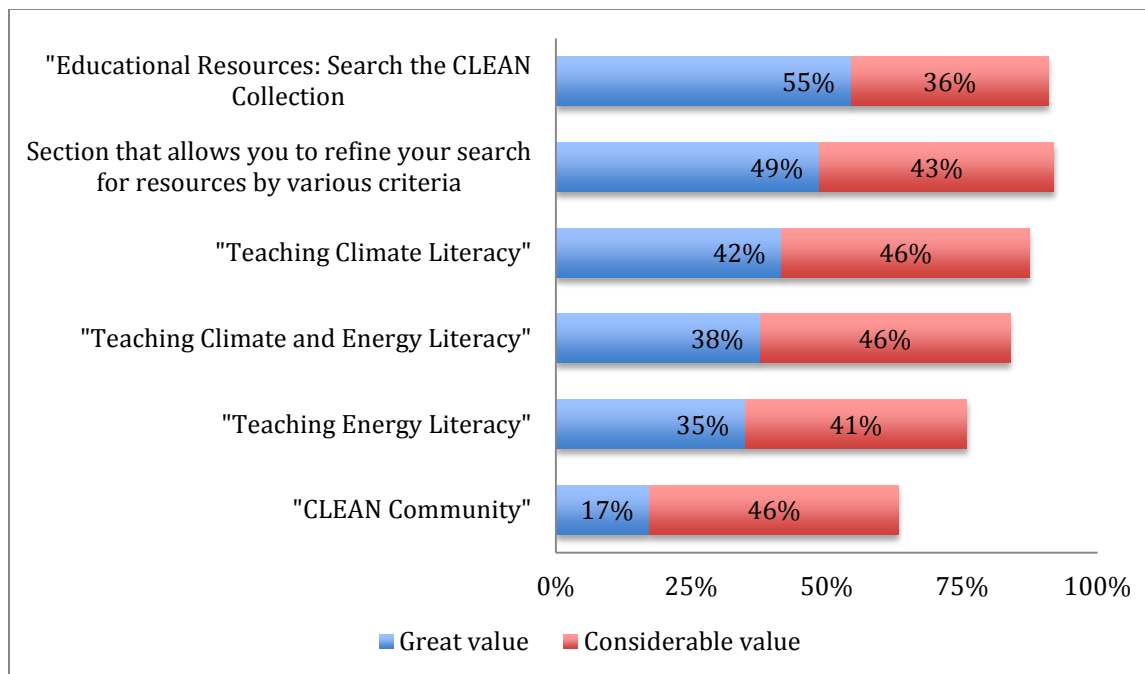
Personal importance of climate change to informants (by level)



Personal importance of energy awareness to informants (by level)



Also on our third survey, we asked informants to rate each section of the website in terms of its value to their teaching. Each section was rated to be of considerable or great value to their teaching by a majority of informants. However, as we often find on surveys about resources, the ratings for “value to my teaching” were slightly lower than the more general ratings for the “quality” of the sections (reported above). We also note that the top- and lowest-rated sections for quality (Educational Resources and CLEAN community) were also top and bottom in these ratings of value for teaching: 91% rated the resources of “considerable” or “great” value while 63% rated the community that highly.



Once our informants learned about the site, they used it on their own. By the time of our second survey, almost 9 in 10 (87%) of our informants had accessed the CLEAN site on their own independent of their consulting work for us, including about half (48%) who had accessed it at least 3 times. Lower division college/university instructors appear to have accessed it less often than others, although the difference in mean ratings by grade level is not significant (34% of lower division informants have accessed it at least 3 times, vs. 48%-54% of informants at other levels).

The great majority of those teaching climate science in 2011-12 (83%) said that they were better prepared to teach climate science this year than they were the year before.⁶ Slightly fewer (71%) said they were better prepared to teach energy awareness. New knowledge and/or resources from the CLEAN website contributed at least a small extent to the preparation of nearly all of the informants responding to our question about contributors to informant knowledge in 2011-12 (94% of those teaching climate science, 87% teaching energy awareness).

Looking more closely at the CLEAN website's contribution to informants' teaching at different levels, we saw that at all levels except upper division university, new knowledge/resources from CLEAN influenced the teaching of climate science by about 3 in 5 teachers by at least to some extent. The influence of CLEAN on the teaching of energy awareness was a little different; a larger proportion of informants teaching at both

⁶ While differences in responses across teaching levels were not statistically significant, they point to a general finding in our study – that change is happening more at the middle school level than in higher grades. Ninety-one percent (91%) of the middle school teachers who answered the question said they were better prepared, as did 89% of the high school teachers. Fewer lower level university informants (70%) and upper level university informants (64%) said they were better prepared this year.

secondary levels (68% middle school, 62% high school) were influenced to at least some extent than were lower division (28%) and upper division (20%) informants.

Looking for a specific resource seemed to bolster informant confidence in the value of the CLEAN website. Over half of the informants agreed strongly that the experiment of looking for a specific resource on the website made them more confident they can use it to find resources they can use in their teaching (56%) and that the content on the website could help them generate new ways of teaching about the climate (55%). Forty-six percent expected to access the CLEAN website more that school year than they did the year before (46%).

After they made these judgments, we invited informants to comment on the general quality of the CLEAN website. Seventy-four informants provided their comments. In general, reflecting the ratings in this section, the comments were quite positive. The positive comments ranged from quite general statements like: *“Excellent website and resources!”* to more detailed descriptions of what they liked in particular: *“The website strikes me as well organized, and provides information that allows teachers to quickly determine whether a resource is appropriate for the topic and age they are teaching. The site provides a wealth of related links to help teachers explore or supplement different aspects of a topic. The guiding principles provide a framework by which I can organize my thoughts and my materials.”* Several informants commented that they especially appreciated the fact that the activities are reviewed by scientists, and that they could read their assessments of the strengths and weaknesses of the activities.

The comments that were less positive contained, for the most part, information about problems they had navigating the site, or, in some cases, suggestions for what they thought was missing from the site, or suggestions for improvement.

The Teaching about Climate section of the website received strong ratings for its quality and value. CLEAN staff wondered in particular about user perceptions of the quality of Teaching about Climate and its value to users. A significant number of respondents said it is of high or very high quality and value, with 59% saying it is of very high quality and 43% saying it is of very high value to them.

In interviews, field experts reported that the collection is of great value to the community of climate and energy educators. Some sample comments include:

I think it is one of the few places that you can go where you can really get a lot of different ideas, it is really a one stop shop kind of thing and there aren't very many other places that offer that... It is good for everybody that is in climate change education, because they are aware of the collection and they can point people in that direction, when people are looking for resources. I think there is a lot of value to that, and I think it is going to be more important as climate education becomes more and more important.

I am a teacher and I want to use climate as an integrating discipline, and you have done most of my work for me. You have made it easy – you have brought the fruit down to where I can just reach out and pluck it. You have given me no reason not to go there and do it, and so, that is huge.... Another reason I value CLEAN is that you are not allowing this big investment that the federal government has made go to waste – you are extending its shelf life and its utility. It is a modest investment on top of an already much larger investment, and to me that is good government. It would not be moral to do otherwise, quite frankly.

Areas for improvement of the CLEAN website

On Survey 2, we invited informants to comment on their experience using the website to find a resource for which they provided a rating. We have already provided some information about informants' concerns with the site and suggestions for improvement. Here we report specifically on comments offered on the second survey regarding areas for improvement.

Thirty-eight informants provided their comments. Overall, comments were mixed across the board. At almost every teaching level, however, there was at least one comment about a lack of appropriate technology in their contexts to utilize the activity they searched for.

Below we provide a few sample comments by grade level, that were shared with CLEAN staff:

Middle School:

I was almost on "materials overload" ...there is so much to explore here.

In many "Teaching Tips" and "Pedagogy" sections there is either inaccurate information about assessment practices and no information about how to use these materials with diverse urban learners, especially language learners and students with common disabilities.

High School:

I appreciate the teaching tips section, but I notice this before I notice the green section with the description of the activity. That can be a bit confusing. Also, in the description, I would like to quickly know if it is pencil/paper, class discussion, computer simulation, game, etc. Last, I would appreciate it more if you really differentiated by middle/high school. I searched by high school, but most of the activities I found were listed as middle/high. This causes two problems: One, is the activity really appropriate for my students? Two, is there overlap with what our middle school teachers do? They have agreed to use only middle school activities they find (so we don't repeat in high school), but when activities are listed for both, how do we know?

More diagrams would be helpful for demos, just so the setup is correct when I try it in my classroom.

Engineering is lacking on the website. Green engineering is a growing field and that should be addressed here.

I especially like the Notes from Reviewers section. It highlights how to best use the resource and problems that may be encountered. A wonderful time-saving addition not usually seen on these types of websites.

Because I work with teachers from grades 3-12 as well as college level students, it is nice to find a website that allows me to find what I need for any grade level all in one place. Most of the college level students I work with are non-science students who don't have a strong background in science and the website allows me to help them better understand the science behind GW and alternative energies in a non-threatening way.

2-year College

The activity [I found] was designed for students living in Chicago. There was a link that one could use to calculate the sun's angle for a different location, but the units were not the same on the activity sheet and the link <http://www.susdesign.com/sunangle/>. This could be an issue for some instructors. It would be helpful to include a link(s) on how to make (or buy) the necessary lab equipment for this activity. For example, what exactly was used as the "translucent screen"?

Lower-division Undergraduate

There was a lack of good videos for renewable energy, but other topics were covered well.

There were not a lot of great activities to teach the concept of tipping points.

The main problem was technology available, since we have switched to mobile devices for teaching and learning and almost universally the activities that used computers didn't work.

Upper-division Undergraduate

The only issue I found was that many of the exercises were created several years ago and have not been updated.

In my opinion, I find the collection is more about pushing renewables and climate policy than providing the scientific and non-scientific information necessary to create effective, just, equitable and sustainable solutions to our energy problems and global change issues.

I am less likely to point students to sites that are loaded down with ads. Some Windows to the Universe sites are overburdened with targeted ads that clearly use cookies or histories from prior web activity for me, and this was very disconcerting to me. I would be less likely to recommend their sites on that basis, but know that this is not CLEAN's decision.

Graduate

...Regarding the search capability, I selected Disagree because I feel that the textbox search functionality could be improved. On a previous page of this questionnaire I described my experience when I accidentally must have refined the search results. My suggestion is to revamp the "Current Search Limits" area into a matrix or branching tree that clearly displays the number of activities at each filter level. Had I not realized my mistake in searching, I would have considered the CLEAN site to be a bit resource-spartan.

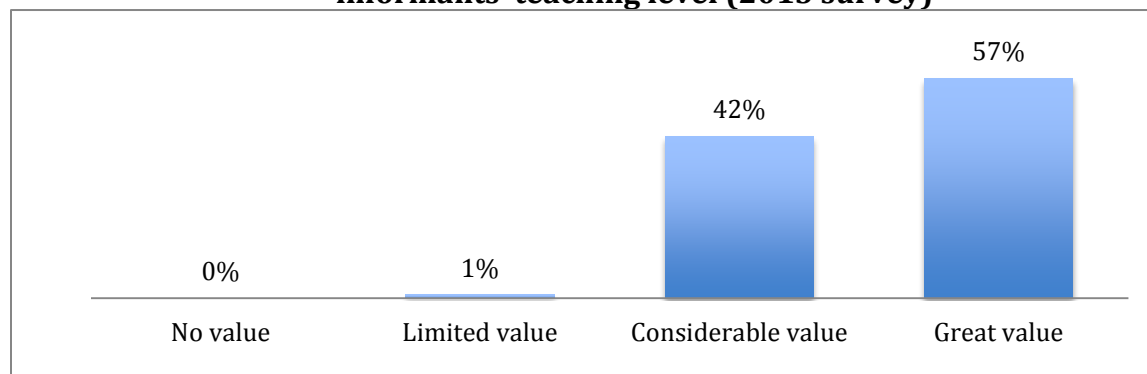
Divert time money and effort to Web design and perhaps a more cladistic organization in your menu system, depend more on graphic symbols before information rather than News Article formats. Follow the three-click rule for finding what you are looking for. Find a symbol like "Google Earth" that can be recognized easily and get an "App" approved by Apple at least so that you are one click away from an IPAD or MacPro desktop. If you can simplify your menu system to work on an IPAD I think you will understand what I am trying to communicate about the graphics and easy user interface. Go for Apple before Microsoft platform because a large number of instructors use Microsoft but carry a personal MacPro. See if you can get a video or program into ITUNES UNIVERSITY or any other Free Self Education Websites like Kahn academy etc. because that is where people are trying to self educate. Don't depend on putting the word out in traditional journals; get yourself out on stage (desktop, iPad, smartphone, apps etc.). Do a Steve Jobs on your website: Make it Look Good, Make it The Place To Go. Make it so damn intuitive even us old professors can use it. And if possible make it fun.

Make it clear that this is not just for science education specialists, but for anyone who teaches topics related to earth surface processes (oceanography, meteorology, geology, geography). At other education websites I am often overwhelmed by the amount of materials available for trained teachers vs. for university faculty who teach. One thing I like about the CLEAN website is that it is topic oriented and the educator-based jargon is minimized (terms like scaffolding and rubric are not everywhere I look).

Are they likely to recommend the collection to others?

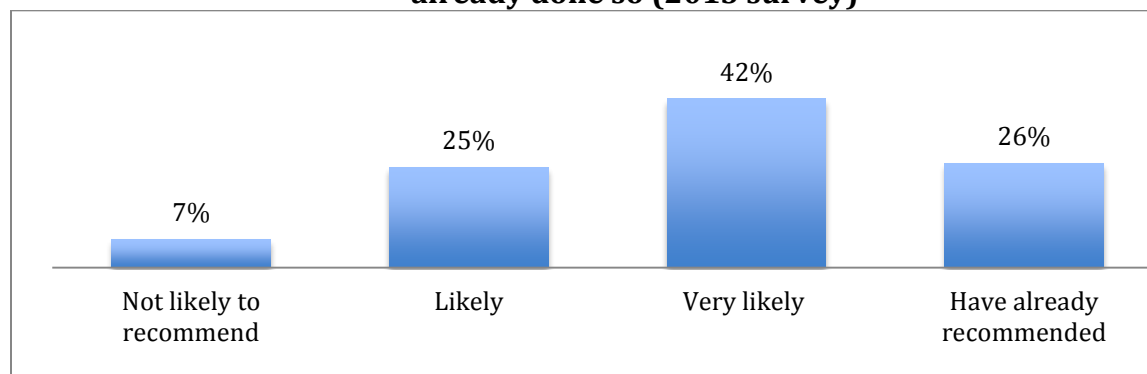
The informants are nearly unanimous in giving high ratings to the potential value of the CLEAN website to other educators at their level.

Ratings of the potential value of the CLEAN website overall to other educators at the informants' teaching level (2013 survey)



Informants were not only likely to recommend the collection to others, many had already done so. On Survey 2, 70% agreed strongly that they would recommend the website to colleagues, and almost all of the rest (29%) agreed. On Survey 3, 26% said that they had already shared CLEAN website resources with colleagues, and almost all the rest were very likely (42%) or likely (25%) to do so.

% of informants who are likely to recommend CLEAN resources to colleagues or have already done so (2013 survey)



This suggests a role for CLEAN in serving as a central communication point for teachers interested in improving their climate knowledge or teaching practices.

Summary of Quality and Value of the CLEAN Collection and Supports

The quality of the CLEAN collection overall was rated as good to excellent by the informant group. The main sections of the website were rated as good to excellent, with the Resources, and teaching support sections rated highest and the CLEAN community pages rated lowest.

Informants value the collection both because they care about the issues and topics it addresses and because it contributes to their instruction. In their view, the collection addresses topics and issues of personal interest to the great majority of our user group.

Their ratings of the main sections of the website with respect to value mirrored the ratings of quality, though slightly lower.

CLEAN contributed to teachers' preparation to teach about the climate in part by providing new knowledge and instructional resources. Informants feel confident that they can find resources they can use and expect to access the site more in the future.

Many comments about suggestions for improvement focused on missing topics or approaches, while a few pushed for better design of the interface and search capabilities as well as more up-to-date resources.

Informants rate the value of CLEAN to their colleagues as considerable or great. And, many were already recommending, or planning to recommend the site to others.

Finally, the Review Camp process and review criteria, while time- and dollar-intensive, is a key outcome of the CLEAN project, and continues to be documented and shared with the field.

D. IMPACT OF THE CLEAN COLLECTION AND SUPPORTS

In this section we explore the question: In what ways do the supports provided by CLEAN enhance the ability of participants' knowledge of and/or ability to teach effectively about the climate and energy awareness?

The Impact of the CLEAN Resource Collection

In the third and final survey (2013), informants were asked to rate the extent to which they felt that the CLEAN collection was positively impacting the nature and quality of their teaching about climate and/or energy. Eighty-two (82%) percent of informants noted that it was having a positive impact on their teaching to at least some extent. Many of those who were not impacted explained that they were not teaching these topics this year. In the explanation of their rating, many informants noted that simply having so many resources in one place is a major benefit, and knowing that the resources have been heavily vetted is also important. Sample comments include:

I am becoming better informed. I know I am getting quality material. It is also saving me time in planning my lessons. I think you need to get the word out more. Present at state and national conferences. I wonder if the Next Generation of Science Standards will allow us to teach more on this subject matter.

– Middle School Teacher

It has allowed me to use more hands on approaches with students around climate change.

– Middle School Teacher

CLEAN resources make it possible for me to teach climate science. I don't know that I would have the energy to find the resources on my own. The fact that CLEAN provides

multiple, varied, and high-quality resources makes the task of teaching climate science do-able.

– Middle School teacher

I like having expert resources that have been tested and verified, tried and validated.

– High School Teacher

I do feel like I'm pretty knowledgeable already and I have certain activities that are built into my curriculum so there is not a lot of room for new materials.

– High School Teacher

Current data, to me, is essential for my students and my classes.

– High School Teacher

I have a lot of knowledge about climate change and I feel that I have a lot of options for teaching about climate science, but I look to this site to mix it up and infuse new ideas.

– High School Teacher

It allows me time to spend on improving my teaching of the subjects because I'm not spending a lot of time searching for quality resources.

– High School Teacher

I have adopted some of the activities for laboratory activities and have used them three times. Student response is good and I think the understanding is better than for previous activities.

– Lower Division Undergraduate

I use the resources here. The materials enhance my class content and improve my own understanding of the materials.

– Lower Division Undergraduate

I think the CLEAN website helps to keep me on track with its thoughtful and thorough framework of what is important (and keeps reminding me to not get too sidetracked). Getting side-tracked is OK once in a while, but with limited meetings with students it helps to have a reliable source to come back to maintain a good course structure. CLEAN is particularly helpful in a "grounding" kind of way since I don't use a textbook and use lots of real-time information...it is difficult to keep up with this method, but highly informative since climate and energy issues are changing so very rapidly.

– Lower Division Undergraduate

I have several reference books on climate change as well as access to IPCC report. However, I found this web page quite helpful when I am putting together a lesson plan within a short time.

– Lower Division Undergraduate

As much as I think I know about climate, there always seems to be more for me to learn in order to pass that on to my students. Some of the resources available I use just for myself!

– Upper Division Undergraduate

We have already provided data from the informant group about the extent and ways they access, use, and value the CLEAN collection. Here we report on the knowledge and beliefs

about climate and energy based on selected questions about the science and socio-political issues surrounding these topics. While educators' views on the reality of climate change have not changed, some educators knowledge and beliefs about the causes and/or optimum ways to respond have changed in the last two years, especially at the middle school level. Fifty-five percent say that their opinions have changed, including 6% who say they have to a large extent, 14% whose opinions have changed to some extent, and 36% whose opinions have changed to a small extent.

A sample of comments about how knowledge and beliefs have changed and what sources of information contributed to those changes reveals that there is a wide range of sources that instructors are attending to as their knowledge and beliefs change. One source that seems to be prevalent is personal experience or observation. Several mentioned CLEAN as a source. A few example comments are below:

First of all only a fool would say that climate change is not happening, but to what extent is the question, and are humans directly involved in massive climate shifts? The answers appear to be no at this time and with current data. Furthermore, my views have changed drastically because I first thought that the science behind global warming was iffy but now realize it is crap science put crudely. The Earth is not warming but there is significant change happening – our planet is dynamic and there has always been change. We do not know if we are directly the cause or the effect. When mass media outlets get involved in education we should always be alert. Just think of it in terms of finding Bigfoot!

– Middle school teacher

I feel more knowledgeable about the anthropogenic causes and effects of climate change. CLEAN, NASA Global Climate Change, NOAA, Learn More About Climate.

– Middle school teacher

I used to believe the Republican view that it is not happening; now I believe we have conclusive scientific data that man is affecting climate change.

– Middle school teacher

I am more aware just because of maturity and watching changes in the area I have lived all my life. Sources are daily living as well as websites.

– Middle school teacher

I have seen photos of the polar ice caps (looks smaller), read articles about how the polar bears are losing their habitats. Using National Geographic for a lot of this info. The weather patterns in our area seem very different that ten or twenty years ago (my own observations).

– Middle school teacher

My beliefs have changed based on online professional development courses I have taken dealing with the ways that climate change has impacted seasonal changes and behavior patterns in animals and the life cycle changes in plants.

– High school teacher

Three summers ago I took a two-week workshop on Climate Change. By week two, the incredible amount of information started to sink in. It is not a topic that is easily understood. I returned as an educator the following summer for the same workshop. In teaching the material to others, I really began to understand the complexities of climate change.

– High school teacher

I'm still developing, but looking over the CLEANet resources has been really helpful, as has learning from colleagues and from professional development (NSTA conferences).

– High school teacher

There is a lot of evidence of climate change now. The website has been very helpful.

– High School Teacher

Mostly through my professional development activities (workshops) and the professional literature. I can give an example. I read a meteorology/climatology paper on how global land precipitation has changed with time so that wet areas are getting wetter and dry areas are getting drier. Then, in an oceanography workshop I learned that the ocean folks are finding similar happenings over the oceans (with precipitation and evap. regions) so that salty areas are getting saltier, etc. So we're modifying the global water budget and perhaps leaving more NRG in the atmosphere for more frequent, short duration storm events. For me, this awareness has really evolved over the last few years.

– Lower Division Undergraduate

Recent large-scale weather events (Hurricane Sandy) helped drive home the idea that the influence of climate change may occur very quickly in major population centers. Such catastrophes can quickly redistribute and amplify other threats, e.g., release of hazardous waste.

– Lower Division Undergraduate

My thinking has shifted somewhat in that I place more emphasis on adaptation now than I did in the past. I believe that it will take us longer to make necessary reductions in GHGs than I had hoped in the past, so we need to be ready for some inevitable large changes.

– Upper Division Undergraduate

I think that my 'beliefs' as you've framed this are calling into question the language used by many environmental leaders (i.e. - Bill McKibben) that use rhetoric to urge people to action. I think this weakens the scientific communities' ability to effectively convey information based on data and not laden with an agenda. My understanding (not belief) of the physical and chemical reality of climate change has not changed.

– Upper Division Undergraduate

The Impact of the CLEAN-sponsored Professional Development

Two of CLEAN's partners – SERC and TERC – developed and implemented professional development opportunities for potential users of the CLEAN collection. SERC held two online workshops for undergraduate faculty (for 57 total participants), and TERC held 11 webinars for secondary teachers (for 142 teachers, 19 repeat participants, and 15 invited

guests). Both of these efforts were intended to increase participants' climate and/or energy content knowledge, provide ideas and resources for teaching these topics, and increase their awareness of the CLEAN collection.

The 11 TERC webinars for secondary teachers were focused on the explication of each of the Climate Literacy Principles. Each webinar lasted approximately two hours. Internal evaluation of the TERC webinars indicates that the participants found the material and interaction highly beneficial. Participants found the expert speakers' presentation to be useful, and the exploration of the CLEAN resources helpful. Feedback reports were generated following each webinar, and the results of these reports were distributed to and discussed by the project leadership.

The four SERC workshops, each held over a two-week period, were also well received by the participants. In particular, the combination of strong presenters, compelling content, and good program design was noted as a highlight. Additional information about the SERC and TERC professional development efforts and their impact on participants can be found in the projects' internal evaluation archives.

Two field experts we interviewed were familiar with the professional development efforts of the project, and made the following comments:

I was really impressed with the webinar that I was involved with. I honestly don't remember the name of the software, but it was really terrifically flexible and it worked really well... I was able to see Tony Leiserowitz's presentation and it is great. It worked really well, so I had a little bit of experience from the receiving end as well as the delivery end.... there is this concurrent chat going on along the side that you can be involved with as well as just listening to these presentations ...it actually really helped and I got the sense that it was the kind of thing that could really help build community.

My general impression is that those [workshops and webinars] are really valuable and that those were for me as a participant, those catalyzed future work that I actually did rather than just thinking I will do in the future, and so it made me put in the time and the effort to do something that I have been thinking about getting done for a long time. I appreciated that quite a lot and it provided ways to connect with other people, so I have a very positive view of those professional development workshops.

Project leaders have documented the work and impact of the professional development efforts in papers and presentations in an effort to share their experience and lessons learned with the field.⁷

⁷ Kirk, K., et al. 2012. The CLEAN Workshop Series: Promoting Effective Pedagogy for Teaching Undergraduate Climate Science, Abstract ED42A-04, presented at 2012 Fall Meeting, AGU, San Francisco, Calif, 3-7 Dec.

Kirk, K. B., et al. 2011. Supporting Undergraduate Research in Climate and Energy with Professional Development for Faculty, presented at the paper 2011 Annual Geological Society of America Meeting, 43(5), p255.

While not a large part of the project budget and effort, the CLEAN professional development was substantial and important work that both introduced the CLEAN collection to targeted audiences as well as provided an opportunity for the CLEAN leadership team to get feedback about the collection and how to best support teachers in their use of the site.

The Impact of Building a CLEAN Community

The CLEAN project was in part built on a burgeoning community of climate education stakeholders formed by the (then) Climate Literacy Network. Over time, as CLEAN began reaching out to the climate and energy education communities for resource collection and review, professional development participation, and other purposes, this community deepened and expanded. In early 2013, the CLN became the CLEAN Network. Our first survey found that there was strong interest in the Climate Literacy Network as a way to participate in the CLEAN community. About 9 in 10 informants are interested in participating in the CLEAN community, and 74% are interested in the CLN. A substantial minority of secondary level informants are also interested in discussion forums and volunteer opportunities. There is clearly a desire among educators for connection. The listserv (>400 subscribers since 2008) and weekly teleconferences (>20 per conference on average) are ongoing as of this writing, where members share information about useful news, resources, conferences, meetings and other opportunities for collective impact.

There were also numerous new relationships that formed as a result of project activities, in particular the resource collection and review activities. This work was intensive and by necessity collaborative – people worked together to discuss the merits of the resources they were reviewing. Furthermore, the professional development opportunities provided a forum for educators from across the country to interact and share their ideas and practices. In summative interviews, project PIs reported the various ways the CLEAN project has enabled and catalyzed a range of new collaborative work in the climate education field:

There are lots of new collaborations spinning off of this and not even really related to this, but lots of new collaborations going on that are from this same group of people and so that is great; that is a huge asset.

CLEAN helped galvanize a lot of different people, CLEAN... put that all in one place and so the climate literacies live here and the resources are here.

As a lurker on the email list serve, I have a much better idea about who is out there doing what in climate literacy, and so I feel like if I wanted to or had a need to contact people in different areas, then I would have a place to go that could be very efficient to

Kirk, K. B., et al. 2012. Teaching Controversies: Lessons Learned from the CLEAN Climate Communication Workshop, presented at the paper 2012 Annual Geological Society of America Meeting, 44(7), p46.

Grogan, M., et al. 2012. Climate Literacy and Energy Awareness Network (CLEAN) - Interactive Webinars for Teacher Professional Development, Abstract ED23A-0737, presented at 2012 Fall Meeting, AGU, San Francisco, Calif, 3-7 Dec.

find people. Recently a connection has been made with one of the people on the listserv through another circuitous kind of route, about teaching a course project on climate literacy, so I feel like there are lots of cross connections.

If NOAA really is successful in sustaining the funding for CLEAN then that collaboration is an important outcome of this project.

If you include the Climate Literacy Network as part of the CLEAN project, it has really galvanized the climate education community to have important discussions about climate education and to advocate for climate education as part of the Next Generation Science Standards and other threats to climate education that come down the pike. It has made us more collaborative and deepened our community; it is more effective and deeper.

People at the Climate and Energy Literacy Summit talked about the potential for using MOOCS, the Massive Open Online Courses. For instance, since climate and energy topics are an integral part of the Next Generation Science Standards, there will be literally tens or hundreds of thousands of teachers scrambling to try to understand the content themselves and to get a handle on the pedagogical practices. So there has been some discussion about MOOCS that could use some of the resources in CLEAN, particularly the interactives.

The people that I came in contact with, the scientists that I have met pulling together these webinars, and the folks at CIRES, and actually one of them was not related to this project, but just the folks out there doing climate science, exposure to the work of people who now I track regularly. I am not a climate scientist, and I don't have a background in geosciences, but it has always been an interest ... I have learned a huge amount, which has been really great and I have met some wonderful people and made some contacts that I will keep.

One PI in particular noted the ways CLEAN raised the capacity of everyone involved, from the project leadership, to reviewers, to users:

There is a community of people who have increased their ability. There is professional development for everybody who is involved, and not only the people who have participated in formal professional development, but the reviewers and the scientists who have participated in review, the educators who are learning about high-quality resources and the scientists who are learning about high-quality education, I call it a professional development outcome. I would say the evaluation data from all of the work that we have done on the gaps and thin-spot analysis is a document that can inform development of resources. The community platform and resource that CLEAN represents for the rest of the climate and energy education community means they don't have to reinvent the wheel to be part of a digital collection or to develop review processes. ... We have got the infrastructure. And then furthermore if you include the Climate Literacy Network as part of the CLEAN project, it has really galvanized the climate education community to have important discussions about climate education

and to be a voice or to advocate for climate education as part of the Next Generation Science Standards and other threats to climate education that come down the pike. [CLEAN] has just made us more collaborative and deepened our community.

Summary of the Impact of the CLEAN Collection and Supports

CLEAN is having at least some impact on the nature and quality of the instruction of informants. Middle school teachers in particular noted that without CLEAN, they would be doing much less in this area. For high school and college educators, CLEAN has helped deepen their knowledge in some areas and increased their teaching repertoire.

Significantly, CLEAN has contributed to changing the views on climate change for some informants, along with a general increase in interest and attention to lived experience and current information about a rapidly changing field.

The professional development efforts of the CLEAN project had a strong impact on the people who experienced it, either as a participant or a presenter. The workshops and webinars were a successful way to orient new users to the collection and for them to learn more about what teachers find important and useful in a climate education resource.

Finally, the CLEAN community, while relatively young, is already having an impact on the people who are part of it, as well as on the field. In addition to new and generative relationships that were formed as a result of the project, the CLEAN Network has made a broader impact through such activities as weighing in on national policy documents (e.g. the Next Generation Science Standards), and engaging additional audiences at professional meetings.

E. THE LANDSCAPE OF CLIMATE SCIENCE AND ENERGY AWARENESS EDUCATION

We include this section in this report because it represents a major part of the data collected from the informants to provide the CLEAN project with a grounded sense of its target audience. Over the years, the informants provided information to the project about their teaching context and teaching practice; resource access, use, and quality; supports for teaching; and the stability of the field. This information helped the project leaders think about the kinds of issues teachers were facing and what role the CLEAN collection could play in addressing those issues.

Also in this section we also include comments from field experts and project PIs about their perceptions of the climate and energy education landscape.

Teaching Practice

Most of our informants have taught or are still teaching both climate science and energy awareness. The exact figures shift from survey to survey because we asked the question slightly differently each survey because of the surveys' different purposes.

% of informants who have taught climate science and/or energy awareness

	Survey 1 – Jan. 2011: “taught in the last 3 years”	Survey 2 – Dec. 2011: “teaching this year”	Survey 3 – March 2013: “taught in last two years”
N	212	173	152
Both climate science and energy awareness	75%	46%	63%
Climate science only	12%	18%	13%
Energy awareness only	6%	13%	6%
Neither climate science nor energy awareness	8%	23%	18%

As might be expected, more informants at the post-secondary level teach just one topic (generally climate science) than at the secondary level.

The majority of courses in which climate science is taught the most are focused equally on scientific aspects and societal dimensions/implications, but nearly as many focus mostly on scientific aspects. The courses in which energy awareness is taught the most focus more on societal dimensions/implications than the courses on climate science.

Informants focus on human impacts on the environment, general science behind climate and energy, climate change in general, and human causes of climate change in their teaching practice. At the middle school level, many also focus on energy conservation.

% of informants who have taught climate science and energy awareness topics in 2013 (N = 112)

	Middle school	High school	Lower division university	Upper division university
Human impacts on the environment	79%	92%	75%	89%
General climate science	88%	83%	78%	83%
General energy awareness	73%	81%	75%	72%
Climate change	77%	74%	78%	78%
Human-caused climate change	65%	77%	88%	78%
Alternative energy	73%	75%	72%	72%
Energy conservation	85%	74%	66%	44%
Sustainability	52%	74%	56%	44%
Solutions to climate change	58%	63%	63%	56%
Regional impacts of climate change	56%	60%	66%	67%
Careers related to climate science and energy awareness	42%	54%	25%	28%
Other content areas taught in last three years	2%	1%	16%	11%

It is not clear if the lower-rated topics are rated lower due to lack of knowledge, quality materials, alignment with standards, etc. Instructors are focused on general science of climate and energy, and human impacts and causes.

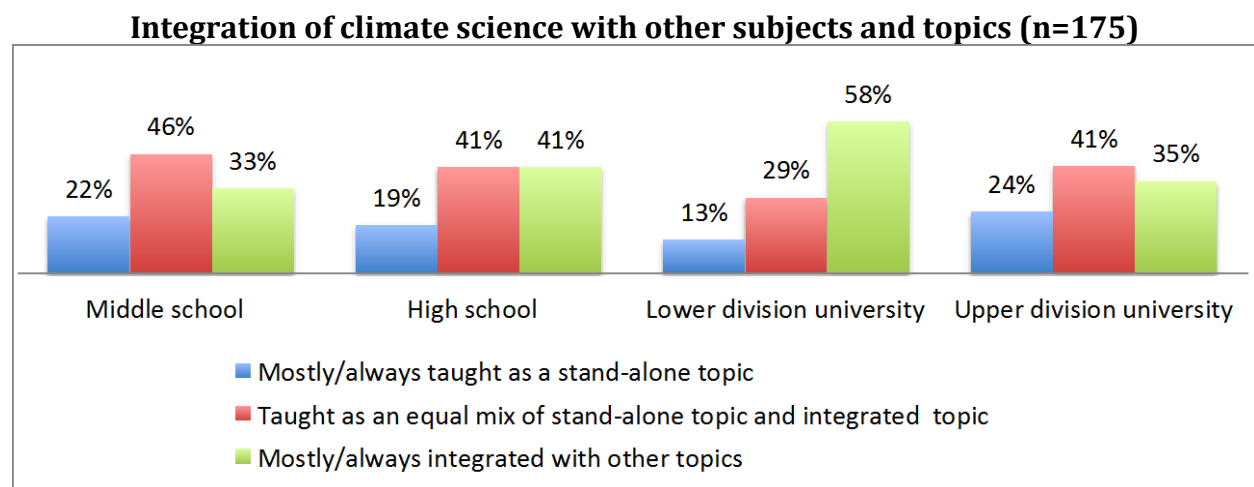
Instructional modes

The mix of instructional modes our informants use seems pretty typical of classroom instruction generally. There is little difference in the use of the top instructional modes at the various levels, with 7 in 10 university educators, for example, using hands-on activities. At all levels, discussion is a very frequently used instructional mode, with hands-on activities used as often as discussion at the secondary level, and lecture used even more frequently than discussion at the lower division university level. Interestingly, (perhaps due to smaller sections) the use of lecture declines at the upper division level.

	Middle school	High school	Lower division university	Upper division university
Discussion	89%	84%	87%	94%
Hands-on activities	89%	82%	70%	71%
Lecture	52%	78%	97%	71%
Lab	39%	55%	50%	53%
Student research	48%	46%	53%	59%
Field work	24%	22%	23%	12%
Other instructional approach(es)	11%	15%	23%	12%

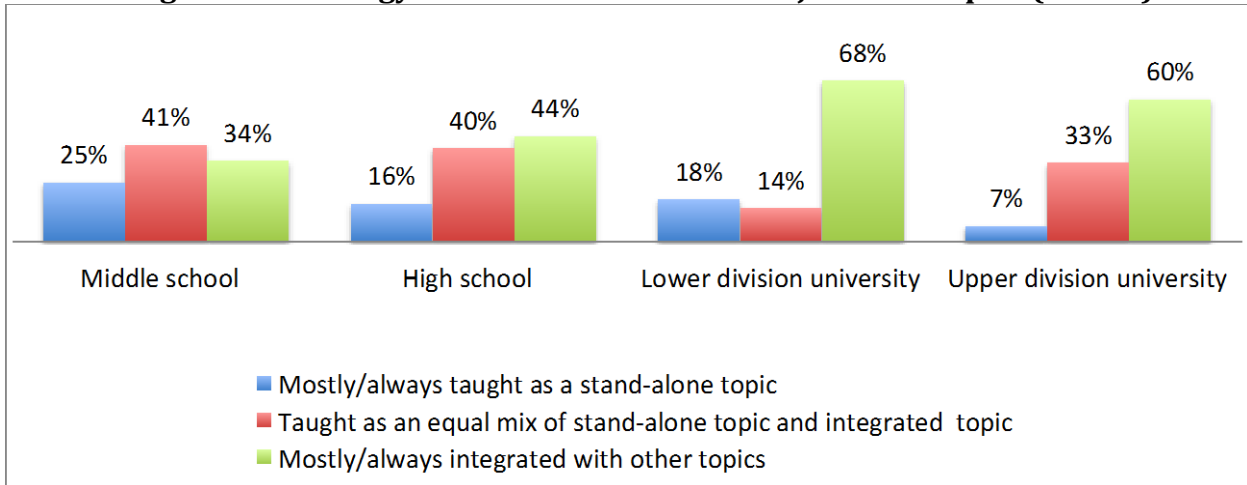
Stand-alone or integrated topics

Climate science is taught mostly as an equal mix of stand-alone topics and integrated with other subjects at both secondary and higher education levels. Energy awareness is more often integrated with other subjects, and mostly integrated with other topics in higher education.



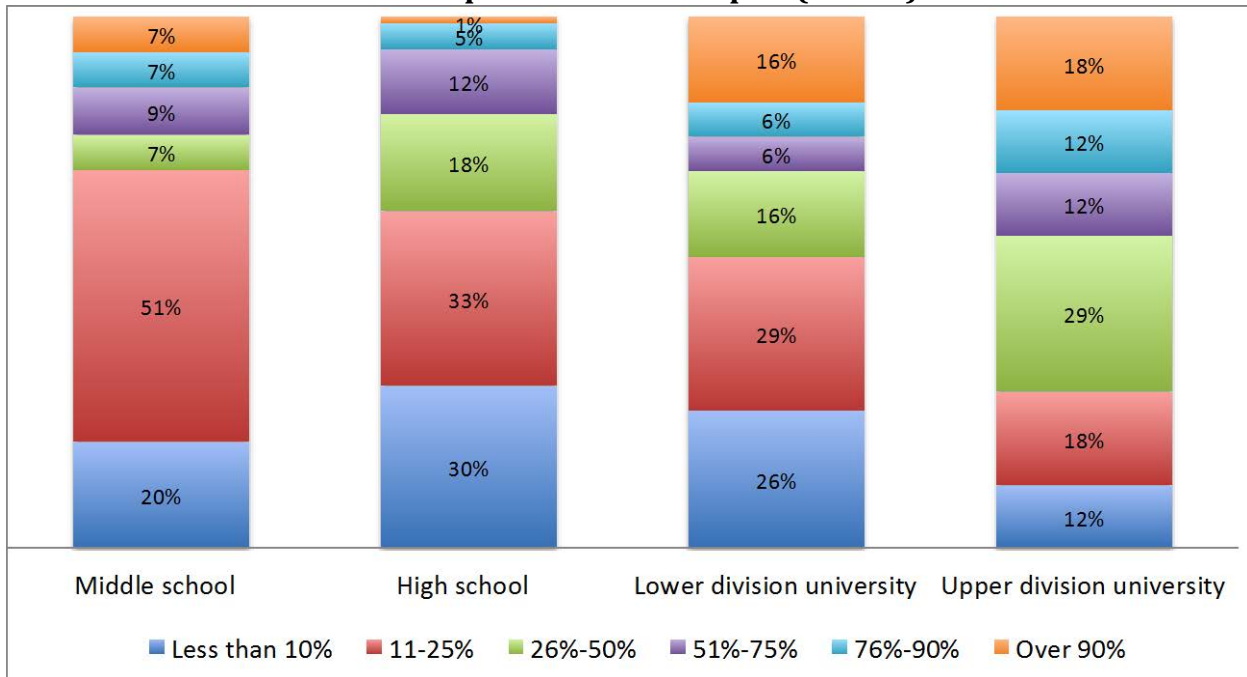
To simplify this graph and the one below, we combined “only” and “mostly” ratings; only a small handful of informants teach these subjects always as a stand-alone. A few more always integrate it.

Integration of energy awareness with other subjects and topics (N=168)

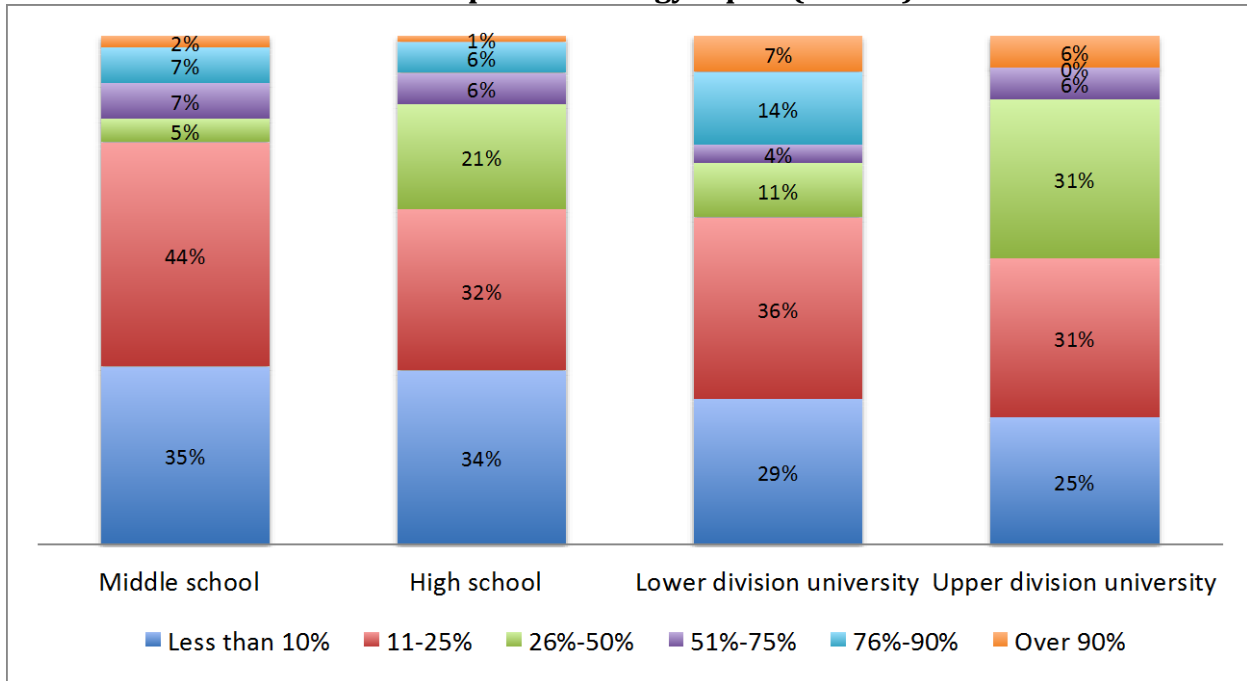


The majority of informants spend less than 25% of their instructional time on climate and energy topics – with more time given to climate topics. However, as might be expected, the proportion of time devoted to the topics is greater at the postsecondary level than at the secondary level.

% time spent on climate topics (N=175)



% time spent on energy topics (N=169)



Other findings related to teaching practice:

- A large majority of informants are confident teaching about climate and energy awareness content and are able to connect concepts they teach into a larger framework.
- In 2011 about half of the informants were familiar with and influenced by Climate Literacy Essential Principles.
- There is a sizable minority that focuses on science alone in the course in which they teach most about climate science or energy awareness. But most want to focus on both.
- Almost all informants consider solutions in their teaching of climate science and energy awareness. They include solutions to a greater extent when teaching energy awareness than when teaching climate science, especially at the upper division university level.
- Informants focus on human impacts on the environment, general science behind climate and energy, climate change in general, and human causes of climate change in their teaching practice. At the middle school level, many also focus on energy conservation.

Informants' challenges and successes teaching climate and/or energy

In the first survey, informants were invited to provide examples of both challenges and successes; 83% (n=176) responded. In terms of challenges, almost half of the informants who answered this question said that the biggest challenges they face are student beliefs (along with parents' and a few colleague's beliefs), misconceptions, pre-conceived ideas, political views, and religious views.

Approximately 1/3 of the informants who commented said they faced challenges that were related to curriculum, instruction, and the lack of time to cover climate science and energy awareness within the courses/classes they teach. One respondent said, for example: *"My curriculum is tied to state testing. Climate and Energy is not covered on our test."* Another said, *"[A challenge is] lack of time to integrate current research into teaching materials and assignments."*

Twenty-six respondents said that the challenge for them related to a lack of resources, textbooks or activities. The remainder of responses varied from, *"students don't have computers,"* to *"keeping up with energy policies and international negotiations"* and *"being knowledgeable enough to teach with confidence."*

Seventy-eight percent of the informants (n=167) shared their successes. Well over half of those who commented said that they've had success with their students. They believe their students have become more aware and engaged, better informed and better able to make connections. One informant reported success as *"getting students actively engaged in meaningful, informed discussion about content."* Another said, *"I think that if students understand the issue, have a feel for the evidence and can comprehend possible outcomes I have been successful. I feel I have met those goals."*

Twenty-five percent of respondents who commented reported having success in their classrooms by integrating climate science and energy awareness into their existing curriculum, and finding good resources and activities to use with their students. One noted:

By connecting this within the physical science curriculum I have been able to bring it in without really labeling it "climate science" which has helped me to keep some of the pre-conceived notions out of the equation.

The remaining responses varied, including such examples as having "civil discussions with parents who believe climate science is a hoax," winning a grant, and students making a presentation to the school board about how the district could achieve \$50K in energy savings.

Barriers to teaching climate science and energy awareness

On our second survey, we explored barriers to teaching climate science and energy awareness. With respect to climate science, we found that the perceived understanding/knowledge by the public have caused more than a quarter of the

informants to change their teaching in a major or minor way. Also, student and/or parent beliefs about climate change, particularly skepticism about the role of human activity in climate change (39% had changed their teaching because of this issue) and the lack of teaching resources to help them address the conflicting messages about climate change in the mass media (which has affected the teaching of 30% of the informants) have been barriers. Upper division is where the highest proportion of educators experienced these as barriers.

When we looked more closely to see how many informants experience no barriers, how many are responding to just a few, and how many are modifying their teaching in response to multiple barriers we found that 65% modified their teaching of climate science in response to at least one barrier. About a third (35%) experience no barriers, a third experience between 1 and 3 barriers (33%), and a third experience 4 or more barriers. Nearly half of the high school informants (45%) report that they experience no barriers, compared to only one of the 10 upper division university informants who answered the question.

No single issue posed as much of a barrier to teaching energy awareness as parent and student skepticism about climate change.⁸ The proportion who say other specific barriers affect their teaching in a major or minor way are very similar to the proportions who told us earlier that specific barriers impacted their teaching of climate science. Fewer informants experience barriers teaching energy awareness due to at least one barrier (38%) than experienced barriers teaching climate science (65% changed their teaching of climate science due to at least one barrier).

Resources

Individual activities and videos are among the most frequently used resources for teaching climate science and energy awareness at all levels. At the secondary level educators draw from materials obtained from professional development for climate science, but not energy. At the postsecondary level, educators rely on research articles on both topics. Real scientific data ranks in the top five at each level, except for middle school energy awareness resources.

Among the top five considerations at all four levels when choosing a resource are the quality of the science, real world applicability, and opportunities for students to use real data and to have hands-on engagement. Cost and alignment with standards or benchmarks are in the top five only at the middle school level, whereas science topics covered are in the top five only at the university upper division level.

⁸ Note that for energy awareness we asked about selected barriers – but not all barriers – that were included in the same question regarding climate science. For example, we did not ask about student and parent skepticism (the most frequent barrier affecting teaching of climate science) because it did not seem as relevant with regard to energy awareness.

On our first survey, instructors reported that they find resources for teaching about climate science on the Internet (Google), conferences and workshops, and current events. The majority also created resources themselves. As noted in “Need, Access, and Use” below, this is one area that changed the most over the course of our study. Most informants at all levels modify the resources they use in some way, as opposed to using them as originally designed.

Informants were asked to list a “trusted source” they turn to for help with teaching about the climate and energy. For trusted sources about the climate, NOAA was named most often with 13 mentions, NASA was next with 9, USGS had 6, GLOBE and SERC each had 3, and DLESE, EPA, NREL, Union of Concerned Scientists, and RealClimate.org each had 2. In terms of trusted sources for teaching about energy awareness, there were no clear patterns, but a few sources stood out: NEED was mentioned by 7 informants, followed by DOE (4), EIA (4), USGS (3), NASA (3), and NOAA (3).

Technology available for use in instruction is presumably changing rapidly, although we did not ask about it again in 2013 because we had more pressing questions. In 2011 our informants told us that 60% of them have access to computers, (lap-tops, mobile carts, computer labs, etc.) and the Internet, which is not far from the national average.⁹ About 20% said they have Smartboards or Smart Classrooms. Roughly the same number have projectors and/or document cameras. Less than 10% of respondents said they had access to a weather station or weather-related equipment. About 10% mentioned basic lab equipment. Other equipment named include: solar panels, Vernier probes, data loggers, wave boxes, light meters, student response clickers, groundwater pollution demonstrator, GPS handhelds, and fuel cell car.

Supports

A large majority feel that they are supported by their school or institution to at least some extent in teaching climate change and/or energy awareness. Support is highest for both topics at the lower division level, and lowest at the upper division level for those teaching energy awareness.

The majority of informants at all levels participate in professional communities related to climate science and energy awareness. At the university level, membership in energy awareness groups drops for the upper division university instructors in our informant pool.

Most of our informants learn about climate science and energy awareness through a mix of formal and informal opportunities, with an emphasis on the informal, especially at the postsecondary level. Professional development in climate science and energy awareness is generally available to all levels, though a substantial minority (excluded in the graph

⁹ National Center for Education Statistics – Educational Technology.
<http://nces.ed.gov/fastfacts/display.asp?id=46>

below) indicate it is not available or not very available. Ready access to professional development is generally somewhat lower for energy awareness than climate science.

Most informants have had some professional development. At the secondary level, informants most commonly have had professional development in both subjects, or in climate science only. At the postsecondary level, fewer than half of the lower division informants have had any professional development in these subjects, while nearly 3/4 at the upper division level say they have had either professional development in climate science only or both topics. Most professional development happens at workshops or conferences, especially for university informants. Over 1 in 4 who have received professional development, have received it via online courses or modules.

Informants rate professional development in climate science and energy awareness as of good to excellent quality. They rate the value highly as well – mostly saying it is of considerable to great value. Ratings of both quality and value are higher in climate science than in energy awareness. Informants were asked to name a particularly high-quality professional development experience. Responses varied; however, experiences with NEED and ICEE were mentioned 4 times each, and GLOBE, NOAA, CIRES, and NSTA were mentioned 2 times each.

Informants' beliefs and knowledge

Beliefs. As we have noted earlier, most informants at all levels say that climate change and energy awareness are of great importance to them personally.

The great majority (92% in January 2011 and 93% in March 2013) is very sure that climate change is happening.

A large majority (83%) believes that their instruction is impacting their students' concern about climate change and energy sources and usage to a large or great extent. Secondary teachers appear to be slightly more confident about this than post-secondary educators.

Knowledge. Informants are better informed about some aspects of climate change than others. In 2013 over 90% said that they are well informed or very well informed about the causes and consequences of climate change and lifestyle changes they can make to mitigate climate change. About three fourths thought they were at least well informed about how to mitigate climate change (73%) and actions they can take to adapt to climate change (73%). Only about half were well informed about broader scientific thinking about adapting to climate change (e.g., helping species relocate to newly suitable locations, 53%) and the present role of government in mitigating climate change (50%). Middle school teachers were less confident than informants at higher levels in their knowledge about both broader scientific thinking and actions they can take to adapt to climate change.

An exploration of the beliefs and knowledge of the informant group in reference to 2010's "Six America's" study. CLEAN staff asked Inverness Research to include on the second survey a short set of selected questions from the 2010 "Six Americas" study in order to obtain a

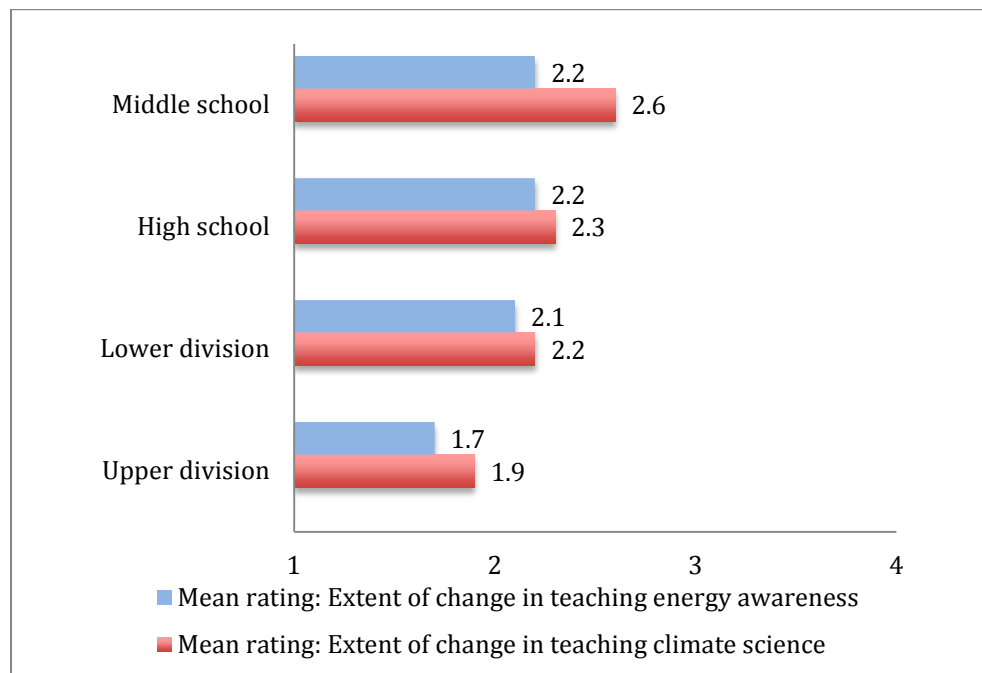
rough measure of the knowledge of our informants about several key facts in climate science.

- Informants are generally well informed about key facts in climate science included on our December 2011 survey.
- Informants are much better informed than the American public on these key facts.
- Informants are most similar in their beliefs/knowledge to the *Alarmed* group as defined by the 2010 Six Americas study.
- Middle school informants are less well informed in some areas than other informants.
- There was little if any change in informant knowledge over the year they had had access to the CLEAN website.

Stability of the field

Supports for teaching climate science and energy awareness are fairly stable, including institutional support, available learning opportunities, quality and usefulness of professional development. While educators' views on the reality of climate change have not changed, some educators knowledge and beliefs about the causes and/or optimum ways to respond, and their instructional approaches have changed in the last two years, especially at the middle school level.

2013 mean ratings of the extent of change in instructional approaches (e.g. lectures, hands on activities, labs) to teaching climate and/or energy in the last two years



1=Not at all, 2=To a small extent, 3=To some extent, 4=To a large extent.

Views on the landscape from field experts

According to field experts we interviewed, the landscape of climate science and energy awareness education is mixed vis-à-vis level of awareness and knowledge about the science and the issues, and in terms of access to and need for professional development. It varies by political culture, by grade level and by region. However, overall there is more awareness and knowledge now than in the recent past. Some sample comments are below:

I think at the college level the landscape probably mirrors somewhat the landscape of public opinion more broadly... it is a little bit of an over simplification to say that it maps neatly onto political outlook, but it does up to a point. So the political landscape, the political map of the US is going to look at least somewhat a bit like the map of climate change acceptance versus rejection.

It is a very heterogeneous picture when you look across the United States, which is some teachers and some schools seem to be more forward-leaning both in their embrace and integration of technology into the classroom as well as their willingness and ability to integrate climate into the classroom as an integrating discipline for teaching some of the fundamental concepts and essential principles that they have to teach and according to their standards. And so you have some that are forward-leaning, and then you have some that are the opposite, are leaning away or recoiling, either due to personal beliefs or pressures or simply lack of time or lack of ability to do that or some combination of all of the above.

I think we are left with a scatter shot picture, where science education in general is teaching the subject in an abstract way, focusing on principles and concepts and not as much about the narrative, not as much about the relevance, the applicability of the knowledge and how it fits together. I think we have a real challenge and a real need and a real opportunity here, which is if we can find a way to get large-scale or even national scale adoption of climate as an integrating discipline in classrooms, there can be several win-win outcomes. One is it serves as an outstanding integrating discipline and framework for teaching about fundamental concepts and central principles, but in a meaningful and relevant and well-contextualized way, and also possibly in a way that is helping people in the longer term as they gain literacy and begin to move up through grades and even into career paths, and to be thinking about how to make choices that are geared towards solutions and ultimately be a part of the solution. And so I think that points to an opportunity that we have, although I recognize it probably has more to do with politics than feasibility in terms of getting penetration into the classroom for that purpose, but I think that is a challenge that we have, both an opportunity and a challenge.

The whole effort is to identify and articulate the climate literacy principles and the energy literacy principles... in terms of organization of people interested in elevating everyone's climate energy literacy, that desire is there and is fairly organized and seems to have gotten much more organized in the last few years. ...There are more and more personal experiences that people have that seem to trigger them to be interested

in climate science, more than they might have before, and there has been a lot of work around climate science communication from the level of detail of what words don't work and who is the messenger and figuring out what kind of messaging works for people coming from different world views and how they think the world should work.

IV. Lessons Learned for Future Investment

In this section we highlight the key lessons learned from the CLEAN Pathways project.

Lessons learned about CLEAN's particular approach to identifying, reviewing, and presenting the resource collection

- While time and money-intensive, the project showed that a process for collecting the highest quality teaching resources can be designed that results in a collection that reflects the needs and interests of educators, and that serves as the pivot point around which a growing community of climate science educators learn and interact.
- Streamlining the process by going on-line helped decrease cost and increase efficiency. There is still work to be done, however, to refine the process in ways that make it exportable.
- The review criteria and review process are a potentially strong contribution to the field, specifically to assist future resource developers as they create new resources for teaching climate and energy or refine existing ones.
- The use of an informant group is a useful strategy for monitoring and providing input and feedback when developing a resource like CLEAN. Understanding user needs and contexts for use can help increase the value of the resources.

Lessons learned about CLEAN audiences and their need for quality instructional resources, and the extent to which a collection such as this meets their needs (or does not)

- Climate science and energy awareness are becoming increasingly important topics for teachers to attend to (i.e. NGSS). CLEAN provides a trustworthy source of guidelines and resources for teaching about the climate and energy.
- Educators said there are adequate resources and they felt adequately informed and confident prior to their use of the CLEAN website – but they perceived that there was room for improvement in the quality of the resources available to them. After using the CLEAN website they overwhelmingly recognized that its carefully vetted and organized resources were of higher quality and value than resources about climate and energy education in general.

- As we have learned in other curriculum-based studies, educators using the CLEAN website tend to modify resources they find there. This has implications for the way resources are presented (e.g., should resources be downloadable in relatively small pieces? Are there some resources that CLEAN experts believe should be used as designed, and if so should they be specially designated? Should CLEAN have a section for people to describe their usage and modification of the resources?).
- It appears the need for CLEAN – and openness to new information and high-quality, usable resources – is highest at the middle school level, more than at the high school or post secondary levels.
- Though information available related to climate is changing quite rapidly, the context for use of CLEAN is pretty stable along at least a couple of important dimensions:
 - The surveyed group continues to teach in roughly the same proportions the same broad sets of courses this year as when they were first surveyed. In 2013 we asked what other classes they teach and found they could potentially be using the CLEAN materials in a wide range of classes and courses.
 - Student interests are pretty stable, with a small gain in interest in solutions. Some of the topics at the top of the list may be the areas where educators can have the most impact because of high student interest.
- Barriers to teaching about the climate and energy awareness stem from a general lack of understanding about the issues by the public and student/parent skepticism about the role of human activity in climate change. This suggests there is a role for the CLEAN community in addressing climate literacy on a larger scale, particularly the media's influence on public understanding of climate. That is, CLEAN could play a role in communication with audiences outside of formal education.
- One of the toughest challenges teachers face is positively affecting student engagement with the topics and enabling them to make connections between concepts in climate science. How can the field better support teachers in this area?
- The success of the online professional development efforts of CLEAN, and the finding from the informant surveys that teachers increase their use of the collection once they are introduced to it, suggests that ongoing outreach efforts by CLEAN to introduce and orient people to the website would support more use in the field.
- Ongoing leadership and shepherding of the growing international CLEAN professional community has strong potential for positive impact on the improvement of climate and energy education.

Lessons learned about the design of the website

- The niche for CLEAN may be in finding high-quality resources and making them very accessible and clearly labeled. Quality may be more important than quantity; planned and carefully selected diversity may be very important where diversity includes level of difficulty, instructional mode, topic, problem vs. solution vs. policy, etc.
- The strategy of addressing both topics in a single website seems to be a savvy choice given the prevalence of many teachers addressing both in their teaching.

Lessons learned about the use of an informant network as an approach to study the development of the CLEAN collection

- The informants have a large number of professional and collegial links – and considerable expertise (e.g., participation in professional groups, providing outreach), supporting our observation that this is an engaged group in relation to the issues of climate science and energy awareness. Thus, this informant pool should not be seen only as potential consumers of the CLEAN collection; rather the capacity and commitment of this group begs the question of how CLEAN can best utilize the knowledge and experience of practitioners like our informant group to help publicize and improve the collection and the website further, even on an ongoing basis.
- When asked on Survey 2 to offer suggestions on a particular section of the website, half of those who responded provided specific suggestions – speaking to the desire of the informant group to contribute to the design process – and their faith that the project would take their ideas into consideration.

Other miscellaneous issues surfaced by the informant group

- CLEAN meets lots of needs and interests. At the same time, developers need to remain sensitive to the different needs and interests at different grades.
- The target audience may come to the website with considerable confidence in its knowledge about climate change – though that differs by grade level. The challenge for the website, then, is to make it clear how its contributions augment their prior knowledge. For example, for the most part, informants feel knowledgeable about the causes and consequences of climate change. Fewer feel well-informed about how to minimize climate change and what they can do, and fewer still feel knowledgeable about the present role of the government in minimizing climate change. Postsecondary informants are considerably more confident of their knowledge than secondary informants in each area.

- It is significant that the Internet was reported in the top five sources for both climate and energy for all groups, which suggests that CLEAN should have a strong search engine presence. Colleagues and professional societies are also important sources for information, which suggests that the social networking efforts of CLEAN target spaces and opportunities where educators interact.
- Educators at all levels mostly believe that their instruction is at least somewhat impacting student concern about climate change, energy sources and uses.
- It is clear that most educators want to focus on both the problem and the solutions. Are they focusing less on the policies (e.g., sustainability) and infrastructures (e.g., careers) that create the context within which solutions must be found? What is clear, however, is that instructors are focused on general science of climate and energy, and human impacts and causes. There is a question of how much the collection wants to take on the more sophisticated socio-political context and debate that shapes solutions.
- There is a large effort in CLEAN to help teachers see where the climate topics in the collection align with standards and benchmarks. How will teachers use this information when choosing resources?
- The fact that most of our informants learn about climate science and energy awareness through a mix of formal and informal opportunities with an emphasis on the informal, suggests that the collection should include options that could be used in a personal or informal setting.
- Are the CLEAN materials easily useable in the settings in which educators commonly collaborate? Are there settings in which educators commonly collaborate around climate science and energy awareness where CLEAN Pathway materials are not yet supportive but should be?

Implications For Future Investment

Funders should find ways to support the development of communities of leading educators in a field if they wish to support that field more broadly. The passion and commitment of the educators in our informant group represent a latent asset that can be harnessed and put to use in promoting improvement across the field. Leading teachers are those people who are simultaneously committed to improving their own practice and in furthering the improvement of the collective profession. The CLEAN community represents a latent Networked Improvement community (NIC)¹⁰ that makes the improvement of climate and energy education an investable proposition for those foundations and agencies interested in doing so.

¹⁰ <http://www.carnegiefoundation.org/elibrary/getting-ideas-action-building-networked-improvement-communities-in-education>

CLEAN shows the power of connecting a resource collection, a national network, and professional development. Each supports the other, creating a synergy that results from doing all three in conjunction. Resources not only provide curricular materials but also serve as a focal point for the community; professional development (serving as both a provider and a participant) helps people learn more about climate science as well as heightens their familiarity with the resource collection; and a networked community is a national resource that both contributes to and draws from its members. Funding strategies that combine all these elements are more likely to build a lasting, robust climate and energy education landscape.

APPENDIX A

Selection of the CLEAN Informant Pool September 14, 2010

Response rate to the application form and selection of the informant pool

- 386 people accessed the survey by July 2, the cut date for our preliminary report of July 13.
- By August 23, the date the survey was closed, 575 people had accessed the survey.
- Of these 575, 399 gave responses that were included in the pool from which our informant pool was selected. The other 176 responses were excluded because they were incomplete or lacked contact info, and/or were answered by people who did not want to be included, who teach only elementary classes, or who work outside the U.S.
- 301 of the usable responses designated the secondary level as "the primary level at which you teach or support teachers." Ninety-eight designated college or university.
- 225 informants were selected, [along with back up names if any informants elect not to participate]: 75 post-secondary, 65 middle school, 65 high school, 20 "other" secondary [curriculum developers, professional developers, informal educators, state science education administrators, etc.].
- State, career stage, comments and courses taught, and definite interest in participating were all factors in our hand selection. Where more than one applicant represented a school of district at a particular level [other than a few very large districts], only one was selected.

Grade level distribution of applicants and informant pool

	399 applicants whose responses are usable		225 informants selected **	
Middle school (6-8)	88	22%	65	29%
High school (9-12)	135	34%	65	29%
Other secondary	27	7%	20	9%
Postsecondary	98	25%	75	33%
Elementary-Middle	16	4%	0	0%
Middle-High	15	4%	0	0%
Elementary-High	<u>20</u>	<u>5%</u>	<u>0</u>	<u>0%</u>
TOTAL	399	100%	225	100%

** Note that multi-level teachers were excluded from the informant pool. Also, potential replacements have been identified who may be invited if anyone in the informant pool declines to participate or drop outs (we will match with the drop out as closely as possible).*

Representativeness of the informant pool

We have conducted three preliminary analyses to establish that the informant pool is representative of the applicants: states represented by applicants and informant pool; career stage; and inclusion of climate

science and energy awareness in the most commonly taught class at each level. All three suggest that our informants represent educators interested in climate science.

	Informant pool (N=225)					Applicants (July report, N=386)*
	Middle school	High school	Other secondary	Post- secondary	Total	
1. N of states represented	28	34	16	34	46	46
2. Teaching tenure						
3 years or less	11%	3%	10%	7%	7%	7%
4 - 10 years	25%	40%	15%	40%	33%	33%
11- 20 years	35%	34%	35%	27%	32%	31%
Over 20 years	29%	23%	40%	27%	28%	29%

** We have not yet conducted a full analysis of all application forms, so we used our preliminary report data on 386 applicants for comparison.*

3. Inclusion of climate science and energy awareness in the course taught most frequently at each level

	Secondary informant pool	Secondary applicants (July report)	Post- secondary informant pool	Post- secondary applicants (July report)
Teach Earth/Space Science	61%	60%	NA	NA
Include climate science in E/SS	91%	93%	NA	NA
Include energy awareness in E/SS	86%	82%	NA	NA
Teach Geology	NA	NA	53%	57%
Include climate science in Geology	NA	NA	75%	78%
Include energy awareness in Geology	NA	NA	85%	86%