**Evaluation and Assessment Summary**

This is the second year CMMAP has offered this two-day course. For 2015 we partnered with Victoria Jordan, who teaches 7th grade science in Wellington, to pare down traditional lectures to a minimum. Lecture content is down to just 27% of total course time. We trimmed PowerPoint presentations added structured activities during which pairs or small groups of teachers learned together and “processed” that science content. Many of the new activities are based on materials from Kagan Publishing and Professional Development ([www.kaganonline.com](http://www.kaganonline.com)).

***Pre- and Post- Instruction Content Test***

We developed a set of written learning targets and objectives (attached) for each of the 8 course “blocks,” and administered a short test (also attached) before and after the two-day course. Tests were anonymous but paired so that we could compare pre- and post- answers for individual teachers without collecting names. A summary of the pre- and post- scores is shown below.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Objective | pre-test | post-test | wrong-right | right-wrong | right-right | wrong-wrong |
| Q 1 | 1c | 27% | 93% | 67% | 0% | 27% | 7% |
| Q 2 | 2d | 7% | 53% | 47% | 0% | 7% | 40% |
| Q 3 | 2a | 13% | 37% | 20% | 0% | 13% | 53% |
| Q 4 | 2c | 40% | 60% | 40% | 20% | 20% | 20% |
| Q 5 | 1d | 27% | 87% | 60% | 0% | 27% | 13% |
| Q 6 | 3c | 33% | 87% | 53% | 0% | 33% | 7% |
| Q 7 | 4c | 47% | 73% | 47% | 20% | 27% | 7% |
| Q 8 | 5b | 33% | 80% | 33% | 0% | 20% | 0% |
| Q 9 | 5d | 27% | 67% | 40% | 0% | 13% | 7% |
| Q 10 | 5e | 40% | 60% | 33% | 13% | 27% | 27% |
| Q 11 | 6c | 27% | 53% | 33% | 7% | 20% | 33% |
| Q 12 | 6c | 27% | 20% | 13% | 20% | 7% | 60% |
| Q 13 | 7c | 50% | 67% | 20% | 7% | 27% | 20% |
| Q 14 | 8b | 77% | 90% | 7% | 0% | 53% | 0% |
| ALL |  | 34% | 66% | 37% | 6% | 23% | 21% |

The test shows that we were generally successful in achieving the course objectives: overall scores rose from 34% correct in the pre-test to 66% correct in the post-test. Only two questions of 14 asked garnered fewer than 50% correct answers on the post-test. Even better, we successfully addressed high-priority misconceptions: an average of 37% of respondents changed from incorrect to correct answers, but an average of only 6% of respondents changed from correct to incorrect answers.

Yellow highlighting in the table above indicates problematic data bearing extra attention.

Although participants showed a huge improvement from the pre- to post-test on Question 2 (7% to 53%), 40% of respondents still got this question wrong after the course. Question 2 read “The Earth radiates energy back to space approximately like a blackbody with a temperature of …” Four multiple-choice answers were offered. The correct answer was -18 C. This question was intended to address learning objective 2d: *calculate the Earth’s radiation temperature* as part of our essential learning target 2: *I can explain how energy flows in the climate system*. The value of Earth’s radiating temperature is not important as a “factoid,” but we spent considerable time in lecture and on group activities learning that this temperature results from energy balance at planetary scale. Perhaps we need a better question to assess this learning target.

Respondents had more trouble with Question 3, whose correct answer was “*Carbon dioxide is a powerful* ***greenhouse gas*** *because (b) it has many vibrational states.*” This question targeted learning objective 2a: *Model the vibrational energy of various gasses in the atmosphere.* Respondents answered correctly 13% of the time on the pre-test compared to only 37% on the post-test, with a surprising 20% changing from a correct to incorrect answer. During the group activity we emphasized the behavior of temporary electrical dipoles in stretched or bending CO2 molecules, but fundamentally it’s the availability of multiple modes of vibration that allow the temporary dipole moments to emerge. CO2 is not a polar molecule like water vapor. We will be careful with this misconception in modifying the course next year.

Respondents showed only moderate improvement on Question 4, whose correct answer was “*The total radiation received by the Earth’s surface (a) is about 2/3 emitted infrared from the atmosphere and 1/3 from the Sun.”* This question is quite fundamental to understanding how climate works, and was intended to address essential learning target 2: *I can explain how energy flows in the climate system.*  We’re concerned that only 60% of respondents answered this question correctly after the course and worse, that 20% changed from a correct to an incorrect answer! The most common incorrect answer was that downward radiation from the atmosphere was half of the energy received at the surface rather than 2/3, so maybe we succeeded in transmitting qualitative but not quantitative understanding of this concept.

Another area of concern is indicated by the 20% of respondents who changed from a correct to an incorrect answer on Question 7, whose correct answer is “*The timing of major ice ages has been governed by subtle changes in Earth’s orbital geometry over the past few million years.*” This question was intended to assess learning objective 4c “*Demonstrate how the tilt of Earth’s axis and orbit influence climate.*” The most popular incorrect answer was “*volcanic eruptions throughout geologic time.*” When we revisit course content and pedagogy next year, we will need to pay special attention to this content area.

Finally, we note that respondents had a lot of trouble with Question 12, whose correct answer was “*If China, India, and Africa build industrial economies based on fossil fuels, atmospheric CO2 will reach approximately 1000 ppm by 2100.”* Only 20% of respondents correctly answered this question on the post-test, and 20% changed from the correct to an incorrect response. This question was intended to assess learning objective 6c: *I can explain the relationship between CO2 emissions, concentrations and climate.* The numerical value of the CO2 concentration is not important, but we’re concerned that this content area was not successfully learned. Of the 8 content blocks in the course, this was the only one presented without any formal lecture. The class broke into small groups to read short articles and teach one another about emissions and CO2. We might need to revisit this content delivery area next year, or perhaps the question was not a good gauge of student learning on this topic.

***Class Evaluation (open-ended questions)***

These evaluations were overwhelming positive. Many participants gave kudos for the quality of the content, the combination of different teaching methods, and the many classroom activities that were offered through the website. The assistance of Erin and Aaron was very much appreciated.

Many people commented that the course was too fast-paced, and that they needed more time to “process” what they were learning. Several specifically suggested that the course be expanded to three days in future years. The overall feeling was that the first day was much too fast, and that the second day was more appropriately paced.

Two people thanked us for the inclusion and modeling of pedagogical techniques, especially the Kagan activities, but a number of others objected. A common suggestion was that these are adult learners who want climate science content rather than a teaching methods workshop. Several respondents asked for more climate science content and “Explain” time.

Another repeated suggestion was that we honor both lunches and breaks and refrain for overloading these times with journaling or other class activities. Several people asked for a longer lunch break.