What Do Introductory Meteorology Students Want to Learn?

BY JOHN A. KNOX AND STEVEN A. ACKERMAN

Students in introductory meteorology classes already know a lot more about weather and climate than you think—just ask them. We did!

Which topics should be taught in an introductory meteorology course? The answer seems simple: whatever is included in a standard textbook on the subject. And yet the meteorological canon is not as firm as its counterparts in many other scientific fields. This is at least partly due to the youth and vigor of meteorology, because continual advances reshape our understanding of the subject. Meteorology is still in the canon-building stage.

Who is left out of this canon-building process? The students. Faculty members create the textbooks they buy, and faculty members decide which textbooks (or unpublished notes) are used in their classes. Faculty members also determine the syllabi for their courses. Students may comment on the design of the syllabus and the utility of the text in an end-of-term evaluation. These comments may, in turn, impact future decisions regarding course material and textbooks. But, in our experience, curriculum design in meteorology is a very "top-down process."

Does curriculum design have to be top down? The unspoken assumption is that students are only interested in a handful of flashy topics in our subject, and their superficial interests cannot be the basis for a substantive education in meteorology. For this reason, so the thinking goes, the experts—the faculty—must determine the curriculum.

There is, to our knowledge, no proof that introductory meteorology students care only about, say, tornadoes and hurricanes. Media coverage of weather and climate, from The Weather Channel and local television weather broadcasts to major motion pictures, has exposed the public to a level of meteorological sophistication that was unthinkable just two decades ago. Could it be that faculty members underrate their own students' maturity of interest in meteorology? Do instructors falsely assume that only faculty can, and should, devise a curriculum in this subject?

To help answer these questions, we have conducted surveys of over 750 students in introductory meteorology classes at the University of Georgia and the University of Wisconsin—Madison. Aside from some unpublished surveys of classes at the University of Illinois at Urbana–Champaign, we are not aware of any similar efforts in our field (D. Charlevoix 2003, personal communication). Below, we describe how we gathered the data from the students, what the data appear to tell us about the students and their meteoro-

AFFILIATIONS: KNOX—Driftmier Engineering Center, University of Georgia, Athens, Georgia; ACKERMAN—Department of Atmospheric and Oceanic Sciences, University of Wisconsin—Madison, Madison, Wisconsin
CORRESPONDING AUTHOR: John A. Knox, Faculty of Engineering, Driftmier Engineering Center, University of Georgia, Athens, GA 30602
E-mail: jknox@engr.uga.edu
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logical interests, and what we think the implications are for the future of meteorology education.

THE SURVEY QUESTION. We asked our introductory meteorology students at Georgia and Wisconsin to respond to the following question: What specific question about weather and climate would you most like to have answered in this class?

We conducted these surveys on the first day of the fall 2002 and spring 2003 semesters at Georgia, and at both Georgia and Wisconsin in fall 2003.

We did not ask each student to design an entire semester-long curriculum—a task that would overwhelm even most meteorology majors. Instead, our goal is to find out which *one* topic is most important to each student, and to let the natural spread of responses, or lack thereof, give us a collective sense of students' meteorological interests.

We freely admit that this is an unscientific survey. At Georgia the question was asked after the course syllabus was discussed; at Wisconsin, the question was asked before the syllabus was presented. At Georgia, students self-reported demographic and educational information in addition to answering the survey question on 3 × 5 inch index cards; at Wisconsin, students responded to the survey question on sheets of paper, and later went online to input the demographic information. On the plus side, by coupling the question with self-reported demographic information, we can characterize not only what the students want to know about, but also who they are. (For more information on how to utilize human subjects in research and education, please see the sidebar.)

SURVEY RESULTS. *Student demographics.* The demographic results reveal that the students that were surveyed at both Georgia and Wisconsin represented a typical cross section of students at their institutions, as well as in introductory science courses for nonscience majors. The Georgia students were 57% female, and the top three majors reported were business (24%), education (10%), and journalism (8%). These statistics are within ±1% for the Georgia undergraduate student body as a whole (information available online at www.uga.edu/profile/facts.html; http://irhst40.irp.uga.edu/html/irps/irpb/Degrees-ByYear/FY2004.HTM#S01). Approximately 54% of the respondents were freshmen. Only 5% of Georgia students that were surveyed listed a major in a science, math, or engineering field. A remarkable 45% of the surveyed Georgia students indicates that they took or were taking calculus in high school or college, respectively.

The survey demographics at Wisconsin were slightly skewed, apparently due to the online method of obtaining the information. Approximately 60%

HUMAN SUBJECT RESEARCH PROTOCOL

Improving our teaching requires that we collect and analyze information from our students. This information is often collected through anonymous surveys in our classrooms. Such activities may require the informed consent from participants through a process that includes either a written consent form or an alternative oral procedure.

Universities and colleges have a process to guide faculty on how and when it is necessary to obtain approval for human subject research. These institutional review boards (IRBs) review and approve research involving human subjects in order to protect their rights and welfare. IRB activities provide an affirmation of the scientific and ethical quality of the research and include nonmedical research activities that use human subjects to collect, analyze, and publish data and demographic information. IRB activities may require training sessions and have application deadlines. Guidelines dealing with the protection of human subjects are given in 45 Code of Federal Regulations 46 (45 CFR 46).

A research study may require the review and approval by an IRB if it involves data collected through interpersonal contact, surveys, or other forms of communication. Research is defined in the federal regulations as "a systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge." Individuals participating in a research project must agree to do so. Typically, researchers explain to prospective subjects all that they need to know about participating in the project before the project begins. Federal regulations may require researchers to document individuals' agreement to participate in the research. Requirements vary depending on the nature of the research project.

There are categories of research that are exempt from these protocols, provided that the research does not expose participating subjects to psychological, social, or physical risks. For example, activities that generally do not require IRB approval include 1) activities conducted to improve the quality of teaching in a particular classroom, and 2) classroom activities that teach research methodologies or simulate research activities. Regarding our work described in this article, we interpreted our surveys to fall under the first of these exceptions.

In conducting education research that involves human subjects, it is nevertheless prudent to contact the IRB at your institute or review the federal guidelines given in 45 CFR 46, which can be found online at www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm.

of the respondents were women, versus the 53% in the undergraduate student population as a whole, and no more than 55% in the pool of survey-question respondents (as determined by gender-specific first names). About 37% of the students listed themselves as freshmen. Of the Wisconsin respondents, the most commonly cited majors were journalism (10%), education (7%), and business (6%), whereas psychology, political science, and communication arts were the majors with the largest numbers of students at Wisconsin as a whole (information available online at www.uwalumni.com/onlinewisconsin/2002-2.html).

Wisconsin undergraduates in introductory meteorology classes are apparently more inclined toward science than are Georgia students, with 17% identifying a major that is in science, math, or engineering. However, the relatively small fraction of Wisconsin students who responded to the online survey *and* also listed a major—only about 33% of the entire class, far less than for the Georgia data—suggests that the results for majors at Wisconsin should be interpreted a bit cautiously. For example, science, math, and engineering majors may be disproportionately likely to take part in online surveys.

Table 1. Survey results from introductory meteorology courses at the University of Georgia (UGA, middle column) and the University of Wisconsin—Madison (UW, right-hand column). Only topics with at least 1% of the overall share of responses are listed.

	UGA 2002–03	UW Fall 2003
No. of respondents to survey question	398	370
No. of topics listed in responses	454	455
No. of topics per respondent	1.14	1.23
Percent of topics related to		
Weather forecasting	13	14
Tornadoes	12	10
Precipitation	7	5
Lightning and thunder	6	7
Atmospheric optics	6	4
Clouds	6	4
Tropical cyclones	5	6
Humidity	4	3
Climate change	4	9
Regional climate	3	5
El Niño	3	2
Pressure	3	2
Thunderstorms	2	4
Fronts	2	2
Wind	2	2
Weather variability	1	2
Air–sea interaction	1	1
World climate	—	2
Temperature	—	2
Weather patterns/systems	—	1

Responses by topic. The middle column of Table 1 depicts Georgia students' responses to the survey question. Because the question is open ended, that is, students were able to articulate their own questions instead of choosing from a list, categorizing the responses is inherently somewhat subjective. Despite the explicit wording of the question, some students stated more than one topic in their question, and these multiple topics were all included in the tabulation.

Arguably, the most striking result of the responses is the prominence of weather forecasting. "How can we predict the weather?" and "why is the meteorologist always so wrong?" are the most common type of questions asked by Georgia students, despite the heavy emphasis on tornado chasing in media depictions of meteorology. Surprisingly, severe weather accounts only for roughly 25% of all topics listed by the students. Another surprise is the sizable number of questions about atmospheric optics, such as "why is the sky blue?" Notable for its absence is the extratropical cyclone—a staple of the meteorology curriculum. This absence may be attributable to a lack of awareness on the part of new-to-meteorology students regarding the role of the frontal cyclone in causing other, more famous phenomena.

In addition to the responses listed in Table 1, a few Georgia students (<1%) also asked questions reflecting an impressive range of interest and knowledge about weather and climate, including questions relating to biometeorology, turbulence, weather modification, the jet stream, the occurrence of "100

year" storms, fire meteorology, the "rain smell," and the ozone hole.

To illustrate the generality of the results from Georgia, we present the survey results from Wisconsin in the right-hand column in Table 1. The Wisconsin results are strikingly similar to those from Georgia. Weather forecasting is, again, the most-cited topic of interest, followed by tornadoes. Atmospheric optics is ninth in the Wisconsin survey, just ahead of thunderstorms, retaining the same top-ten status it enjoys at Georgia.

One obvious difference is the Wisconsin students' greater awareness of climate compared to Georgia students. Climate change is the third-most-cited topic among Wisconsin students. This may reflect the greater proportion of science students in Wisconsin's introductory meteorology classes. Alternatively, Wisconsin students may be more keenly attuned to climate than Georgia students. Some student questions implied that this heightened awareness was due to the recent spate of warmer, less snowy winters in the Midwest.

Responses by text chapter. Because the topics in the left-hand column of Table 1 were chosen by the first author, we run the risk of bias in the tabulation of the students' responses. To alter any bias, we recategorized the results by the chapter in an introductory meteorology textbook in which the answer to the question would be most likely to appear. The textbook used is Ackerman and Knox (2003), but the results should be relatively text independent (with the exception of this text's chapter on "Observing the atmosphere," which unites atmospheric optics with a discussion of remote sensing techniques).

Table 2 depicts the chapter-by-chapter recategorization of the students' responses. The breadth of student interest is evident, as is the overall similarity in the responses from Georgia and Wisconsin. Students collectively ask questions that span the entire range of introductory meteorology. Severe weather constitutes no more than about 25% of student interest.

DISCUSSION AND CONCLUSIONS.

> Suppose all of the syllabi and curricula and textbooks in the schools disappeared . . . What would you do? We have a possibility for you to consider: suppose that you decide to have the entire 'curriculum' consist of questions. These questions would have to be worth seeking answers to not only from your point of view but, more importantly, from the point of view of the students.
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> —Neil Postman and Charles Weingartner
> *Teaching as a Subversive Activity*

We have outlined here a real-life application of the ideas that are advocated by Postman and Weingartner (1969). The responses received from over 750 students at the University of Georgia and the University of Wisconsin—Madison provide provocative evidence that introductory meteorology students do *not* suffer from "tornado tunnel vision." Instead, their collective interests encompass nearly the entire breadth of meteorology—from weather maps to wind-whipped waves, drought, heat waves in Europe, 100-year storms, and the consequences of global warming.

However, our survey results are obtained from two public universities that are ranked among the top-20 public institutions in the nation, both with average Scholastic Aptitude Test (SAT) scores above 1200. As such, our results may or may not be representative of students at other colleges and universities.

Assuming that our results are broadly representative of all introductory meteorology students, the following are a number of specific results of this survey that deserve emphasis in the context of current pedagogical practice in our field:

- Up to 50% of the students at Georgia have been exposed to calculus. But, introductory meteorology makes no use of the students' mathematical maturity. The vast majority of introductory meteorology textbooks and classes requires only occasional elementary arithmetic.
- Weather forecasting was the consensus number-one topic of interest for students at both Georgia and Wisconsin in our subjective categorization, and was number two in our chapter list. This indicates a strong interest in forecasting that rivals students' better-known fascination with severe weather. But, many textbooks provide a treatment of weather forecasting that lags behind current practice, pales in comparison to what can be found with even a cursory search of the Internet, and is confined to one chapter near the end of the book, and, thus, is crammed into the hectic end of a long semester.
- Atmospheric optical phenomena are one of the most commonly named topics in our survey. But, anecdotal evidence indicates that many instructors limit or even omit this material in introductory meteorology courses.
- Student interest in climate—sometimes seen as the antithesis of tornadocentrism—is significant, particularly at Wisconsin.

These points of emphasis can and should be the starting point for discussion among introductory

meteorology instructors, and also among textbook authors in our field.

Our survey results suggest that an instructor could use students' first-day responses to this type of question and shape a syllabus that would incorporate student interests, while retaining educational integrity. Pedagogical materials are now becoming more flexible, for example, with instructor-unique textbooks made possible via electronic publishing, combined with versatile electronic supplements (e.g., Whittaker and Ackerman 2002). In this more flexible educational environment, a student-influenced curriculum should be relatively easy to implement in the near future.

Finally, our demographic results imply that the students in introductory meteorology courses at our universities are the future leaders in the fields of business, journalism, and education. If meteorology instructors can partner with these students to create more engaging and relevant course curricula, it would benefit the entire discipline of meteorology, as well as society.

TABLE 2. Survey results from introductory meteorology courses at the University of Georgia (UGA, middle column) and the University of Wisconsin—Madison (UW, right-hand column), as categorized by the chapter in Ackerman and Knox (2003), in which the answer would most likely be found.

	UGA 2002–03	UW Fall 2003
No. of respondents to survey	398	370
No. of topics listed in responses	454	455
No. of topics per respondent	1.14	1.23
Percent of topics found in		
Chapter 1: Introduction	3	3
Chapter 2: Energy cycle	0.9	1
Chapter 3: Temperature	1	3
Chapter 4: Water in the atmosphere	15	12
Chapter 5: Observing the atmosphere	7	5
Chapter 6: Atmospheric forces and wind	4	4
Chapter 7: Global-scale winds	0.9	2
Chapter 8: Atmosphere–ocean interactions	10	10
Chapter 9: Air masses and fronts	2	2
Chapter 10: Extratropical cyclones and anticyclones	0.9	2
Chapter 11: Thunderstorms and tornadoes	22	23
Chapter 12: Small-scale winds	0.9	0.5
Chapter 13: Weather forecasting	15	13
Chapter 14: Past and present climates	1	4
Chapter 15: Human influences on climate	5	10

We encourage instructors to survey their own students as we have here, or to consult with campus experts in survey techniques and to improve upon our methods. We also encourage instructors to tabulate the results and report their findings. In the future, we plan to conduct similar surveys in a more rigorous manner, and to teach introductory meteorology using student input to help craft our courses.

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