How Meteorologists Learn to Forecast the Weather

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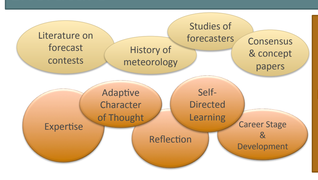
Why Study Forecaster Learning?

- NWS envisions a shift toward decision support.
- Requires a deep conceptual understanding of weather!
  - The *meaning* of all that probabilistic information
  - **"Decision support is a massive scientific challenge: you never know what they're going to ask for next."**
    —*Ken Graham, speaking of NWS decision support to other federal agencies during the Deepwater Horizon incident response.*
- Industries / sectors waking up to value of weather:
  - $200B US Apparel Industry takes action with seasonal forecasting
    - ***"I have been in this industry for 40 years, and during that time, we always knew it got cold in December and stayed that way through January and February — and that was that. Now, it's a crap shoot."***
      What the CEO of Weatherproof (winter coats) said about the $10M insurance policy he purchased against weather. Source NYT 2007.
  - Energy Sector
    - **The energy sector is finally waking up to realize the value of weather. And they're hiring.** —*James Duncan, Conoco Phillips, 2011*

Literature



A great deal of literature on similar learning, and aspects of learning. No big theory.

Why Grounded Theory

- **Grounded theory:** *"Enables the identification and description of phenomena, their main attributes, and the core social, or social psychological process, as well as their interactions in the trajectory of change."* *Source:* Morse et al., 2009, *Developing Grounded Theory, The Second Generation*
- **An inductive process** to identify what is going on
  - Synthesize, develop concepts & generalize
  - Considers context
  - Deal with preconceptions and bias

Eleven Participants

Drawn first through preconceived ways learning might vary, then through theoretical sampling.

Time-in-Service	Sector	Type of Forecasting	Sex
• 3 @ 1 yr • 2 @ ~4 yrs • 3 @ ~8 yrs • 3 @ 17 yrs	• 4 Private • 7 Public	• 6 routine public • 1 hydrology • 1 agriculture • 1 utilities • 1 marine • 1 aviation	• 8 males • 3 females

Added: Sense of Identity — • Strongly as a forecaster (~5) • Mixed with many other life activities (~6)

Assumptions & Limitations

Assumptions
- Learning not overly idiosyncratic to preclude discovering patterns of learning
- Forecasters are sufficiently cognizant of their learning to describe it

Limitations
- Popular opinion of "good" does not guarantee true skill
- Those with poor metacognitive skills are unaware of their incompetence
  - Strategies are less productive
  - Attempting to distinguish "good" and "bad" experts problematic
- Sex and race/ethnicity not well sampled
- Interviews are what people *think* they do

Sources: Sosniak (2006); Kruger & Dunning (1999); Atkinson (1997)

How Forecasters Learn

Being Taught: Strong Support From Experienced Forecasters — 1

37 Stories
84% early learning

- Learning results in:
  - deeper conceptual understanding
  - ability to more quickly focus on key data and processes
- Learning is relatively fast
- Affirmation readily felt, but was not as clear as in Path 2 unless it was *missing*

Made Connections	Janet: Retired forecaster weather observers linked obs to processes.
Learned how to think about it	Raymond: Head forecaster showed what mattered; Tyler: Retiring boss focused last months teaching him; Henry, Lisa: Experienced forecasters got them started; Cassie: Experienced forecaster catching her up. Shawn, Forest, Jordan: Learned marine, aviation.

Breaking Path 1: *Illuminating the underlying affirmation*

Felt unwelcome.	Cassie: Without mentors, shadowed as many forecasters as she could. Distressed at their body language when she asked for help.
No mentor.	Travis: Shadowed all forecasters indiscriminately.

→ Both expressed a desperation to learn all they could as quickly as possible.

Fixing Path 1 by fixing affirmation: Cassie moved offices, is now learning quickly. *"I can expect—every time I'm on shift with this person—that I'm gonna learn a whole bunch of new things. And it's awesome!"*
Travis did not seem to have a better situation in his new office.

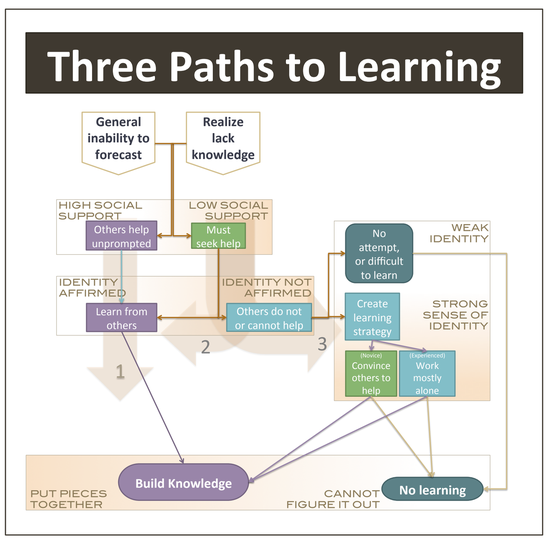
Seeking Help: The Benefit of Social Interaction — 2

26 Stories
65% early learning

- Relatively fast learning
- Mentoring did not readily occur; they sought help

Overcome general inability	Cassie: never lived by ocean; had to keep asking about marine Janet: help readily available when asked Raymond, Forest, Jordan, Tyler: asked questions to further their knowledge
Overcome specific problem	Lisa: asked about a cloud line Shawn: asked about a particular midlatitude instability term Forest: used another's tool for sea fog Mike: consulted colleagues with known specialties

Three Paths to Learning



Create Strategy: Others Do Not (or Cannot) Help — 3

32 Stories
50% early learning

- Longest path to learning (time and steps)
- Participants' most significant learning
- Deliberate actions described as created by them
  - Younger: **build knowledge** — link science to the job
  - Experienced: **extend science** / **build ability** to do job
- Half involved others; half mostly solo efforts
- *Effort not always made; does not always end in learning*

Build Knowledge

Cassie:
- (painfully) aware incompetence in marine
- Marine focal point said, *"go through these modules"*
- Created strategy: *"if I do these...[then] we...talk...and [you] show me...I'll learn a lot better.... And we so we did that. And I feel a lot more comfortable with...the marine side of the forecast now."*

Lisa:
- notices everything
- does not discriminate what is important yet
- *"I want to do [WES cases] at a little bit slower pace and be able to ask a lot of questions as I go through. Because there's things I see on there.... I might see [little features]...or some detail"*

Forest:
- *"I had no formal training there. They just, boom. They said, go ahead."*
- on own time: COMET modules, *Weather & Forecasting*

Build Ability

Shawn:
- weather more severe than he anticipated
- event reviews showed he was missing instability in data
- *"I created a procedure on AWIPS. . . . I've had a couple of forecasters comment to me and say that's an interesting way of looking at the atmosphere."*

Henry:
- *"When you go out into the field you can see the lay of the land and all, just how water comes of particular hills, how it goes and drains down toward a particular city."*
- Also builds relations with emergency managers and others to improve his ability to do well

Build Knowledge & Extend Science

Tyler:
- *"One thing I think I've done...a good job at...is making sure that I save and document work that I do. So, the next year, when...the forecast comes around again, I'm not starting over from zero."*
- Seasonal climate → long delay to feedback

Extend Science

Mike:
- three stories that used same strategy of digging deeply into particular missed events; publishing results

Summary

Learning in formal courses was helpful but not organized for use.

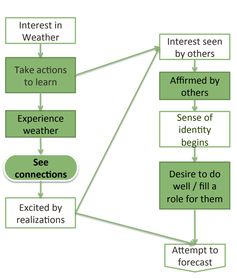
Forecasters were happier, and their knowledge deeper and better connected if they had good social support.

Forecasters learned how to think about the weather and how to effectively use data from other forecasters.

A strong sense of professional identity led to better learning, particularly when forecasters were poorly supported and had to create strategies to learn.

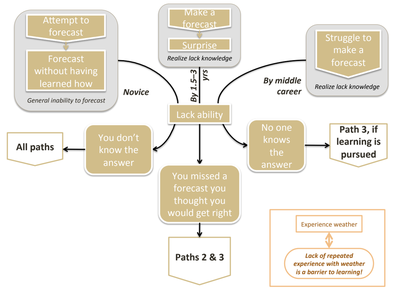
Other Findings

Entry to the Profession



"... my friend was so scared. That I just took it upon me to try to calm her fears . . . I felt a strong urge to comfort her in whatever way I could. . . . I guess that kind of fueled my interest . . . in something I wanted to learn more about [anyway]." —*Cassie*

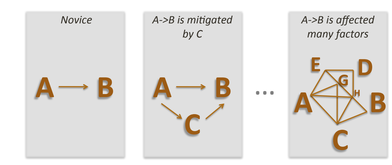
Triggers for Learning by Career Stage



"Because you can look at the model data and it gives you a hint. You can look at the guidance. But it's not always right. And you know you gotta learn from that. And you learn from your mistakes. I learned from my 25 degree temperature errors" —*Forest*

Progression of Understanding

Simple Associations → Increased Complexity, Deeper Understanding, More sophisticated Forecasts



"Probably the most basic change would be in the early years, everything was based on analogs, and pattern recognition, because that's all I had. I didn't have the broader understanding. I have become a little more knowledgeable in the dynamic processes and I can apply that to a pattern and not always come up with what I might have come up with without the dynamic understanding." —*Raymond*