

BEHAVIORAL COGNITIVE PROCESSES OF NOVICES AND EXPERTS DURING FIELD MAPPING ACTIVITIES

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RESEARCH QUESTIONS

This pilot study provides insight into how geology experts differ from novices in completing field-based tasks.

Specifically, we consider:

- 1. What strategies do students and experts use to complete bedrock geology field mapping tasks?**
- 2. Can we measure/compare these strategies via analysis of the spatial patterns used by participants during mapping, and by analysis of their maps?**
- 3. Can we gain insight into these strategies using qualitative data including think-aloud audio logs during participant mapping and follow-up interviews?**

Project Overview:

- Seven participants with a range of prior geologic mapping experience completed bedrock geology maps of two field areas.**
- Maps, field notes, and continuous GPS tracks were collected from all participants.**
- Think-aloud audio logs, digital photos, and follow-up interviews were collected from three participants.**

WHY STUDY EXPERT AND NOVICE GEOLOGISTS IN THE FIELD?

NOVICES

EXPERTS

- **Geoscience Education Research is paying increasing attention to skills and knowledge perceived as intrinsic to geologic expertise.**
- **Unfortunately, we know almost nothing about the transition from novice to expert, and little about the nature of geologic expertise.**
- **Nearly all professional geoscientists have received training in field-oriented tasks.**
- **Most of what we know about expert reasoning in the field is intuitive, or based upon philosophical perspectives or prior work with student (novice) populations.**
- **Understanding the differences between novice and expert cognition, reasoning, and strategies is the first step toward improved field-based teaching**



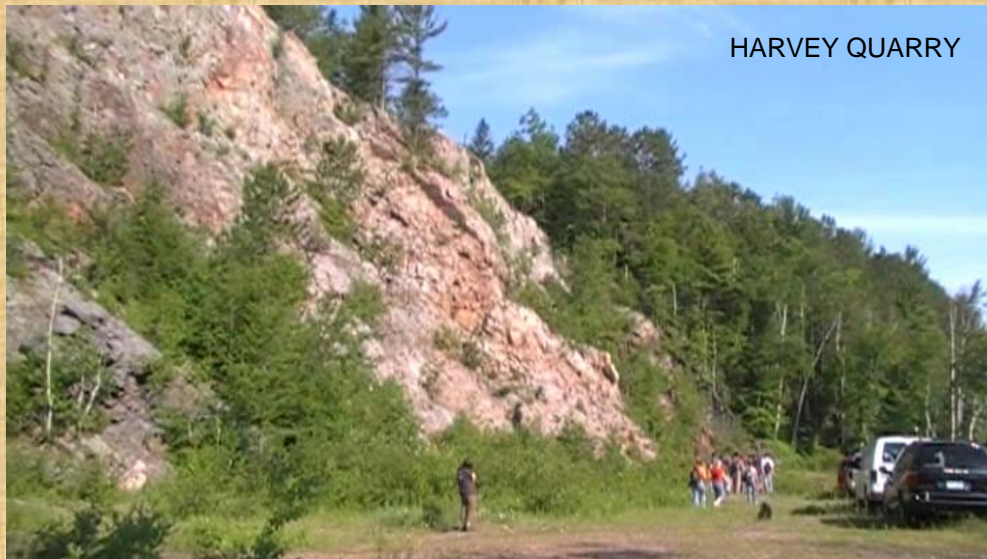
FIELD SITES

The study utilized two field locations near Marquette, MI in the Michigan Upper Peninsula.

Rocks exposed at both sites are distinctive enough that a detailed knowledge of the local geology and stratigraphy was not crucial to mapping the field sites.



Lighthouse Point: Cross-cutting relationships between three rock units on a topographic base map (100 meters x 300 meters).



Harvey Quarry: Seven distinct rock units in a structurally complex syncline exposed in vertical cliffs of a quarry and roadcut. Exposure over a horizontal distance of 1.5 km; site flagged every 100 meters.

METHODOLOGY



PARTICIPANTS:

- Created bedrock geology maps of each site.
- Four subjects participated as part of normal activities in 2-week undergraduate field geology course.
- Three subjects participated one day later, time unlimited.

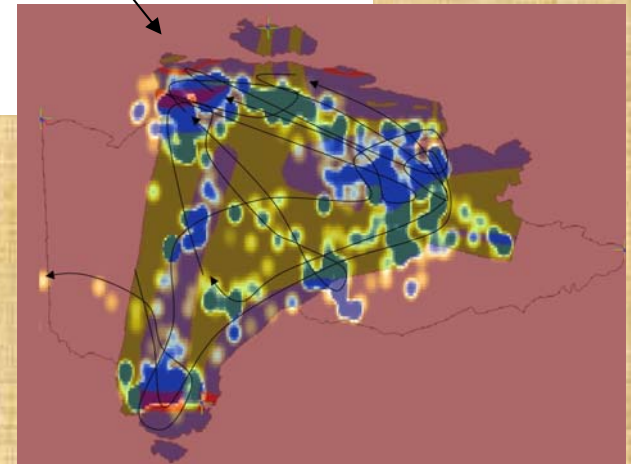
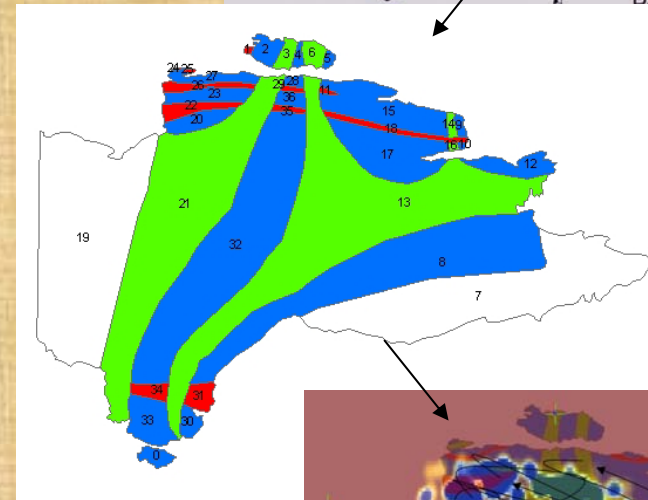
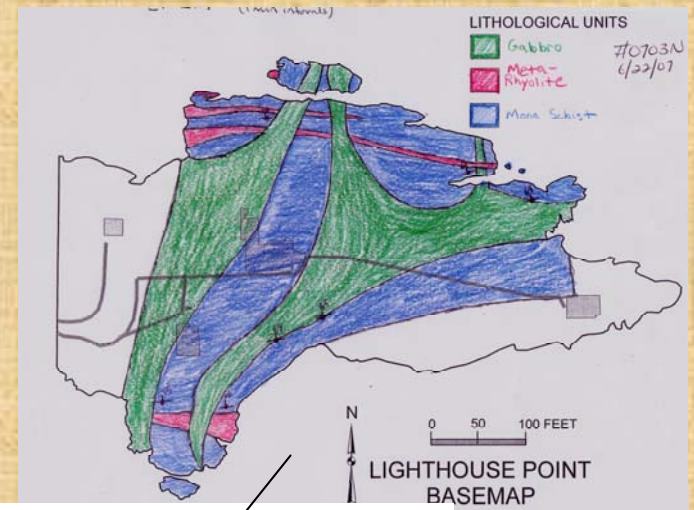
DATA:

- Data collected from all subjects:
 - Background and demographic survey
 - Novelty Space Survey (J. Elkins, personal communication)
 - Draft and final maps
 - Field notes including lithologic descriptions
 - Continuous GPS track record (modified from Lieder, 2005)
- Data collected from three subjects:
 - Audio recordings of thoughts during mapping
 - Digital photographs taken by participants
 - Follow-up interviews

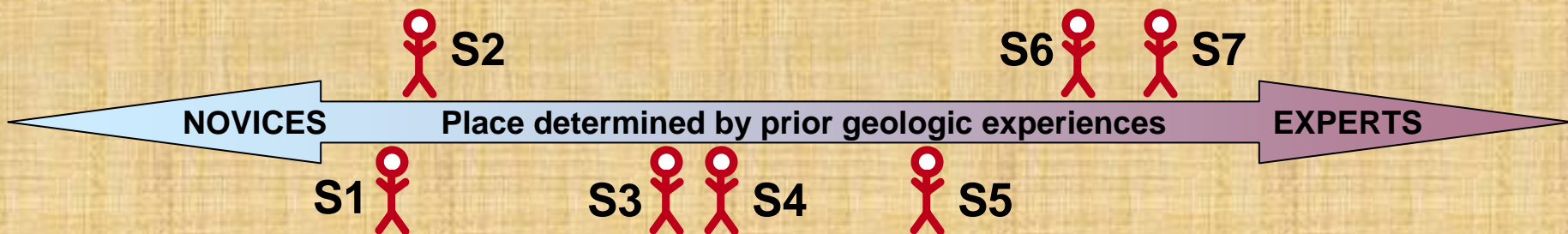
METHODOLOGY

ANALYSES:

- **Maps**
 - Analyzed in ArcGIS 9.2
 - Polygon analyses provided information about total map area devoted to specific rock units.
- **GPS tracks**
 - Analyzed via kernel density analysis
 - Kernel density in ArcGIS was used to calculate the accumulated density of time spent by each participant in the vicinity of each feature
- **Notes, audio logs and interviews**
 - Thematic content analysis with coding emergent from data collected

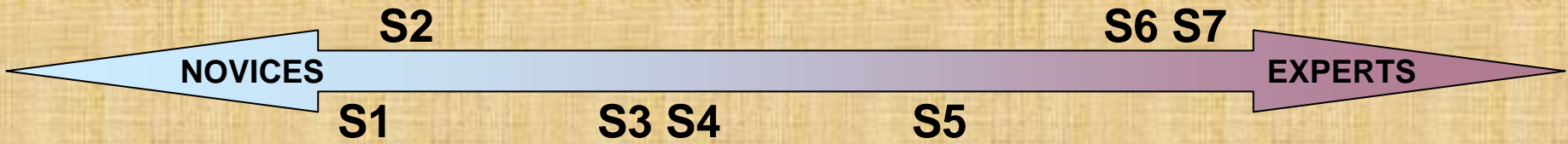


RESULTS: PARTICIPANT DATA



Participant	S1	S2	S3	S4	S5	S6	S7
Demographic	F, 43	F, 34	M, 22	M, 21	F, 25	M, 34	M, 46
Current occupation	Student BA Bio/ Earth Sci	Student PhD Geol	Student BS Geol	Student BS Geol	Student MS Geol	Project Geol, consult (5.5 years)	Assoc Prof Geol (9 years)
Prior geologic mapping experiences, degrees, courses	No map, 3 courses	No map, BS Bio, MS Geol, Intern	No map, 6 courses	No map, 6 courses	Map?, >10 courses	BS Geol, Field course, res, work	BS/MS/ PhD Geol, Field course, res, work

RESULTS: NOVELTY SPACE



Scaled 0-100%, with higher scores reflecting greater novelty

GEOGRAPHIC:

31-61%, except S7 (7%)

COGNITIVE:

S1-S4: 25-34%

S5: 22%

S6 & S7: 16%

PSYCHOLOGICAL:

S1: 16%

S2-S5: 28-38%

S6 & S7: 25%

Overall, cognitive and psychological aspects novelty aspects of field work decrease with increasing experience

COGNITIVE:

“It was difficult... I have never seen it [rocks] in the field, so that was a challenge ‘cause I’ve only seen the perfect little samples”

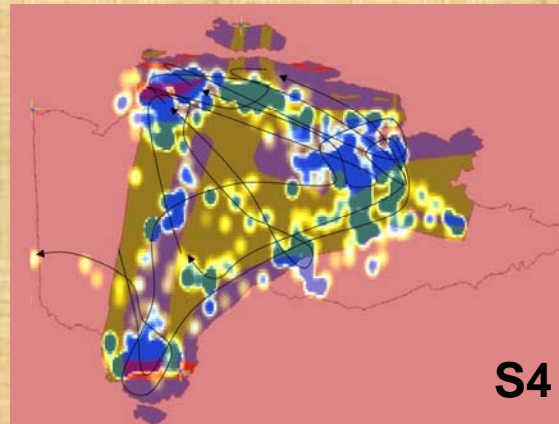
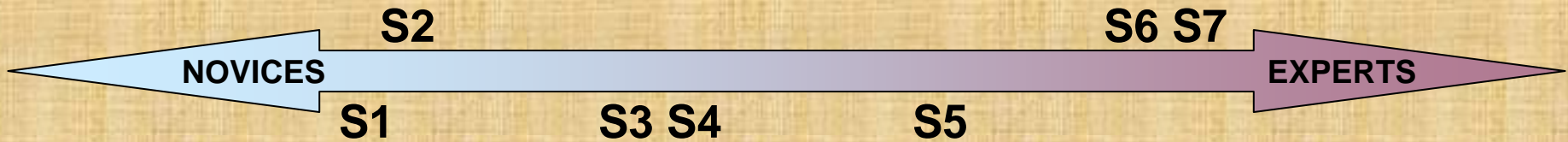
(S2 – HQ interview)

PSYCHOLOGICAL:

“The area that was covered with shrubs... was kinda creepy and I stepped on a dead animal... and I so I didn’t like going through that area. And then this area... was incredibly close to the highway and pretty steep, so I didn’t feel incredibly comfortable at that end.”

(S2 – HQ interview)

RESULTS: MAP AND TRACK ANALYSIS



- Experts display economy of movement during mapping by having simpler movement tracks and less backtracking than novices.
- Kernel density analysis suggests that expert mappers spend more time in key areas, such as contact relationships, faults, etc., than novices.

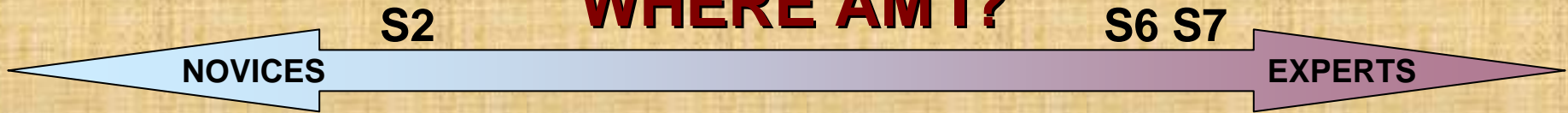
RESULTS: QUALITATIVE DATA ANALYSIS



Preliminary thematic content analysis suggests three main aspects of cognitive processes during field mapping:

- Where am I? Navigation/spatial awareness
 - What am I looking at? Identification
 - What does it all mean? Synthesis
-
- Confidence matters!

WHERE AM I?



Novice: “I had a difficult time finding the flags.” “It kept throwing me off that the actual outcrop was almost a third smaller than the subsurface area.”
[note: map projected subsurface contacts] (HQ interview)

Expert S7: “I think the first thing I might do as far as improving my efficiency will be to walk up at the high point... and have a look over the map area” (LP audio log)

COMMON STRATEGIES

- **Perspective changes:** close to/far away from outcrop
- **Mentions of obvious features;** coastline shapes, lighthouse, marking flags
- **Overview techniques:** walk the transect, get high before mapping, orient self in space and actual distances to be covered
- **Quality of exposure**

- **Novice:** Very little mention of “where am I” – map mis-scaled
- **Expert:** Sense of scale and quality of exposure dictated mapping strategy

WHAT AM I LOOKING AT?

S2

S6 S7

NOVICES

EXPERTS

Novice: “I don’t have a strong background in the field at all so, most of these rock types are a guess – except for basalt.” (HQ interview)

Expert S6: “My basic strategy was to walk the transect, note the lithologies, note the contacts, take a lot of structural measurements, a lot of strike and dips...” (HQ interview)

COMMON STRATEGIES

- Rock orientation – strike/dip
- Identifying rock type (physical tests, layering, colors)
- Rock categories (ig, meta, sed)
- Structural and sed features (faults, fractures, joints, bedding, etc.)
- Certainty plays a role

- **Expert:** Identify contact versus bedding; mention additional data; utilize non-litho (water, veg), weathering, and topographic clues

- **Novice:** weathering got in the way of identification

WHAT DOES IT ALL MEAN?

S2

S6 S7

NOVICES

EXPERTS

Novice: “This appears to be an intrusive rock type... Then there’s faulting... This area contains a series of fractures and faults... it seems to me that these was some serious uplift... but I don’t know if I can generally say there’s one thing going on.” (HQ interview)

Expert S6: “...it was only later, after I made it all the way to the north end and started working my way back that I started to realize all the strikes and dips were pointing toward the center, and I thought, well, it was either a syncline or some kind of repeated section because of faulting. So basically descriptive in the beginning and interpretive toward the end” (HQ interview)

Expert S7: “Continuing back into the woods, there was a beautiful outcrop of stromatolites that are essentially horizontal... so I was speculating that I was in the middle part of a syncline... As I came out of that... I was confused because if this was truly a syncline, then I should come out of the basal part of the stromatolite and back into the slate. I looked around, but the dominant lithology... was... quartzite, so I’m wondering what happened to the slate? ...so I speculated that it’s a fault. (HQ interview)

WHAT DOES IT ALL MEAN?



COMMON STRATEGIES?

- **Novice:** no “big picture” synthesis of data
- **Expert:** themes of synthesizing data to produce tentative and testable models, but each expert used a different approach
 - **Expert S6:** understand contact relationships and how units fit together; initial observations followed by later interpretation; additional data that did not fit model was insufficient to change model, but suggested additional tests for model
 - **Expert S7:** interpret origin of rocks and structural features; infer history of events; made earlier model to test and often changed model based on new evidence

CONCLUSIONS

RESULTS

- Cognitive and psychological aspects of field work become less novel with increasing expertise.
- Map and track data suggest experts display economy of movement and spend more time in key areas.
- Qualitative data suggest that key aspects of cognition for field tasks are:
 - Navigation and spatial awareness
 - Identification of key features
 - Synthesis of data to produce testable models
- Novices and experts use similar strategies to navigate and identify key features, but novices are more hampered by distracting features.
- Experts use different strategies to produce testable models that integrate and explain observations.

CONCLUSIONS

IMPLICATIONS

- **Qualitative data can support (or refute) what is intuitively known about cognition and strategies used during field mapping.**
- **Student field experiences might benefit from explicit instruction about mapping strategies. Physical modeling of expert behavior on the part of students might be helpful.**
- **Much more research on the expert-novice continuum in geosciences is needed:**
 - **Replicate study with additional participants better covering the entire novice-expert continuum**
 - **How do experts from different disciplines compare – are there strategies that all experts use?**
 - **What aspects of field cognition can be taught, and what can only be learned through experience?**

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