Developing and Validating a Space Weather Concept Inventory (SWCI)

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About the Researchers

What is a Concept Inventory?

A **concept inventory (CI)** is a research validated multiple-choice assessment designed to **measure core understanding** and **identify misconceptions** in a subject.

Examples of CIs used in science education include the **Force CI** (Hestenes et al., 1992), the **Geoscience CI** (Libarkin & Anderson, 2005), and the **Earth System Thinking CI** (Soltis and McNeal. 2021).

SWCI Development

Draft Items → Expert Review → Pilot Study (n=250) → EFA (Revise) → Main Study (n=750) → Validate (n=719)

Expert Review

Five Space Weather Experts (private, public, government)

Pilot Study

Initial study had 28 items
Released for 250 participants

Exploratory Factor Analysis (EFA)

The purpose of **EFA** is to look for patterns in how assessment questions are answered, highlighting which items cluster together around common themes of understanding.

How Pilot Testing Informed the SWCI

N = 250

Pilot testing revealed a **primarily unidimensional structure,** with a small secondary clustering of items related to specific geospace phenomena.

Factor 1
Solar-Terrestrial Processes and technological impacts

(*r* = .735)

Factor 2
Specific geospace phenomena

Strong factor correlation suggests participants understand space weather as a **single interconnected system** rather than **separate topics**. Item refinement reduced the instrument from 28 to 24 items for the main study.

Pilot Study **28 Items** (n = 250) → EFA Refinement **4 items removed** → Main Study **24 Items** (n = 750)

Main Study Results

Post data cleaning, n = 719

Psychometric Validation Process

Internal Consistency **Reliability** → Rasch **Item and person fit** → Regression analysis **Performance Predictors**

Internal Consistency Results

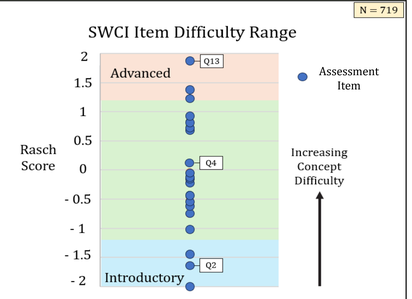
n = 719

Cronbach's α	Item Reliability	Person Reliability
.88	0.99	0.81
(> .70 acceptable*)	(> .90 excellent*)	(> .70 acceptable*)
Items reflect a single coherent dimension of space weather knowledge	Question difficulty rankings would hold up in a similar study	The instrument effectively separates participants by knowledge level

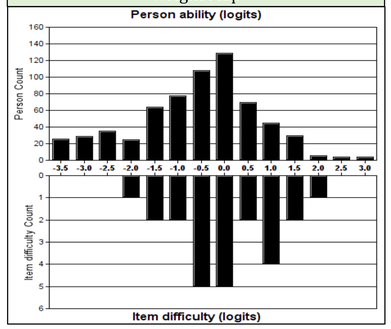
*Thresholds from Allen et al. (2004) and Boone & Scantlebury (2006)

Rasch Analysis Results

N = 719



Wright Map

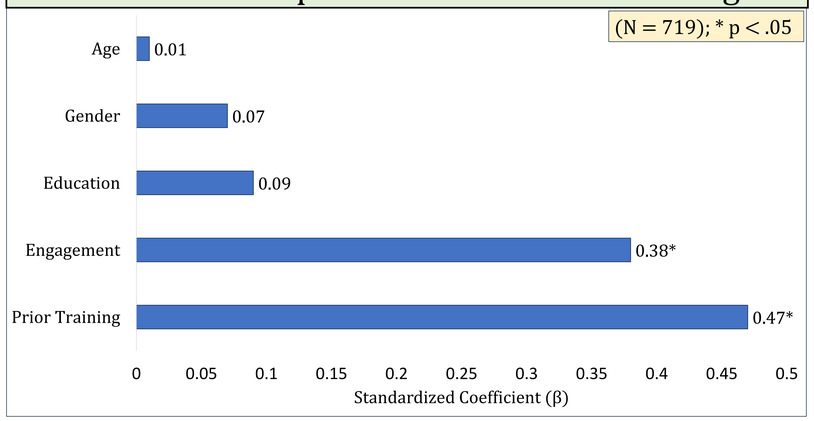


Rasch and Wright Analysis Discussion

Item difficulty ranged from **introductory to advanced concepts**, with most participants clustering in the **moderate ability range** and solid coverage across the central range. Items generally fit the measurement model well, with three showing minor variability in responses. Coverage was more limited at the upper end, suggesting future iterations would benefit from additional challenging items.

Predictors of Space Weather Understanding

(N = 719); * p < .05



What Participants Were Unsure About

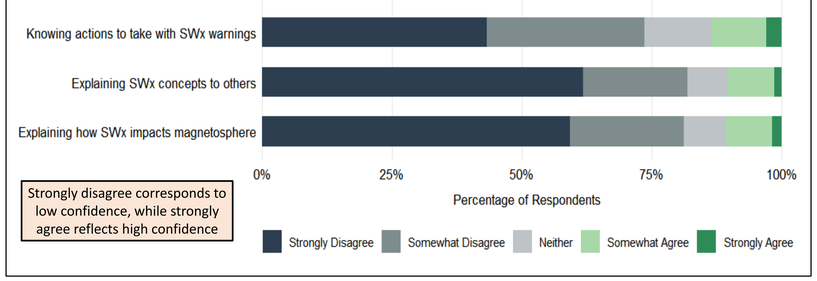
"What is something you've heard about space weather that you aren't sure is true?"

Initial exploratory keyword analysis

Theme	Count	Example
No prior exposure	20.2%	"I didn't even know space weather was a thing"
General uncertainty	16.1%	"The level of danger we face from solar flares - there seems to be conflicting information presented to the public"
Infrastructure impacts	16%	"I heard a giant solar flare could destroy every computer and send us back to the dark ages"
Solar flare and CME confusion	2.6%	"CMEs are like solar flares"
GPS disruption	1.7%	"I've heard that big storms can knock out all GPS globally, but I'm not sure how realistic that is"
Other	43.4%	"Strong solar flares can directly cause earthquakes" "Solar flares can make people feel depressed"

Self-reported confidence across space weather (SWx) literacy items

n = 707



Strongly disagree corresponds to low confidence, while strongly agree reflects high confidence

Discussion and Future Work

Engagement and prior training were the **strongest predictors of space weather understanding,** outperforming demographic variables such as age and gender. Most participants reported little to no prior engagement with space weather information and low confidence across all literacy items. Future work will expand validation with the long-term goal of establishing the SWCI as a **community tool** for assessing and **improving space weather literacy.** A manuscript is currently in preparation for submission in summer 2026.

This research was supported by the Auburn University Department of Geosciences and the McNeal Geocognition Lab. Special thanks to the National Science Foundation for their kind student travel support to this workshop!