Occupational Skills Mapping for 24/7 AI Career Cyber-coaching

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Overview

- Occupational Skills Mapping for 24/7 AI Career Cyber-coaching
  - Team
  - Project overview and goals
  - Stakeholder analysis
- Occupation and Skills Data
  - O*NET and Bureau of Labor and Statistics
- Analysis and Visualization Plans
- Occupation and Skills Mapping Results
- Next Steps for 2022-2023

Current Team

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Overview

Occupational Skills Mapping for 24/7 AI Career Cyber-coaching is apart of the larger Embedded System Security (ESS) / Trusted AI program within the larger SCALE (Scalable Asymmetric Lifecycle Engagement) network.

SCALE is the preeminent U.S. program for semiconductor workforce development in the defense sector. SCALE provides unique courses, mentoring, internship matching and targeted research projects for college students interested in microelectronics at Purdue University, Notre Dame University and Indiana University.

The Trusted AI program addresses the strategic need to for a systematic test and evaluation framework for AI, which is broken down into four hard problems: Human Trust of AI/ML, Measures, Metrics, and Testing, Data Source Bias and Modularity, Cybersecurity & Risk Modeling

Goals

- Workers, career coaches, and employment agencies need actionable insights on the evolving labor market
  - Global understanding of occupations and skills outlooks, employment risks
  - Local, actionable data and resources
- Develop occupation and skills maps that can be used as part of career counseling services to guide workers in response to regional and national labor market trends, supply chain issues, or pandemics.
- Focus on strategic areas of needs…
  - Microelectronic and packaging engineering, embedded systems/system on a chip (soc), supply chains.

Existing Tools in this Space

- BLS Publications and Data
- BLS Tools
    - Career OneStop
        - Get My Future
        - My Skills, My Future
    - O*NET
        - My Next Move
- Industry developed
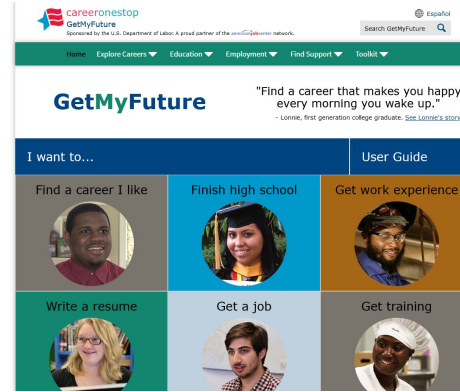
Stakeholder Interviews

We interviewed **7** stakeholders for our project, including

- Radiation Effects and Systems Engineers PIs at NRL & NSWC Crane

- Recruiter NSWC Crane

- Education and workforce development leadership in DoD and DoE

- Electronic Parts Manager for NASA

Stakeholder Interview Insights

- Defense dept strategic research organizations and administration
  - Overlap with DoE and NASA
- Current and future skill requirements for micro-electronics engineers
  - Skills, abilities and knowledge
- Relationships between government and industrial base
- Challenges of new hires in the workforce
- Recruiting and hiring processes for government agencies
  - Current and future needs
  - Strategic pipeline with national coordination, regional execution
- Challenges of hiring managers

Emerging Challenges

- Micro electronics and packaging engineer positions require extensive education, continuous training
  - Unlikely to be impacted negatively by automation, AI, robotics.
- Strategic need is *now*. Recruiting pipelines exist but have challenges with getting US citizen interest.
- Challenges begin at *identifying* and *capturing interests* of HS through undergraduate and graduate school.
- Graduates/new entrants have challenge of navigating government and industry without insider knowledge

Data

Census

- **NAICS** - industrial codes standard that links industry statistics with occupation employment projections.

BLS

- **OCC –** Occupational Classification Standard
- **O*NET –** Detailed occupation profiles with controlled vocabularies.
  - Job tasks, skills, abilities, knowledge, certifications and licensing, personalities
- **Occupational Employment and Wage Statistics Survey**
- **Current Employment Statistics –** Industry and regional employment figures
- **Occupation Employment Projections –** 10 year employment projection for industries and occupations
- **Injuries and Illnesses –** Statistics on workplace injuries by industry and occupation

Burning Glass Jobs Data

- **Current job listings and advertisements -** Job titles and text description, locations, posting dates

Data

Challenges

- Data on impacts of automation, robotics, and AI technologies on workforce is not collected by BLS.

- Need to link national standards (NAICS, OCC) with job titles and descriptions

  - Semantic level comparisons of job titles and descriptions – same meaning but different words.

  - Conceptual fuzziness between skills, abilities, and job tasks

- Strategic-need jobs and skills are novel

  - No clear education programs and pathways

  - Unique, hard to title and describe

  - Institutional knowledge, industry knowledge

- Seasonality vs non-seasonal jobs

Data

Opportunities

- Develop proximal measures of risk and strategic needs
    - Current employment, employment projections, injuries/illness/fatalities, job postings, skill commonality/rarity, salary
    - Industry, national and regional projections
- NLP data preparation methods that allow differentiation of skills, abilities and tasks found in job descriptions.
- Job title and occupational classification matching and industry
    - Fuzzy matching of occupation titles and current job titles from advertisements.

Data Analysis

- Occupation and skill multi-edge networks
    - Hierarchal network – industry, job families, occupations, job titles
    - Undirected, bimodal adjacency networks
- Risk Measure associated with skills and occupations
    - Skill risk to automation, AI/ML, robots
    - BLS Occupation projects for employment opportunities
- Strategic Need Score for skills and occupations
    - Skill demand and associated income ranges
    - Essential skill – common skills associated with many occupations
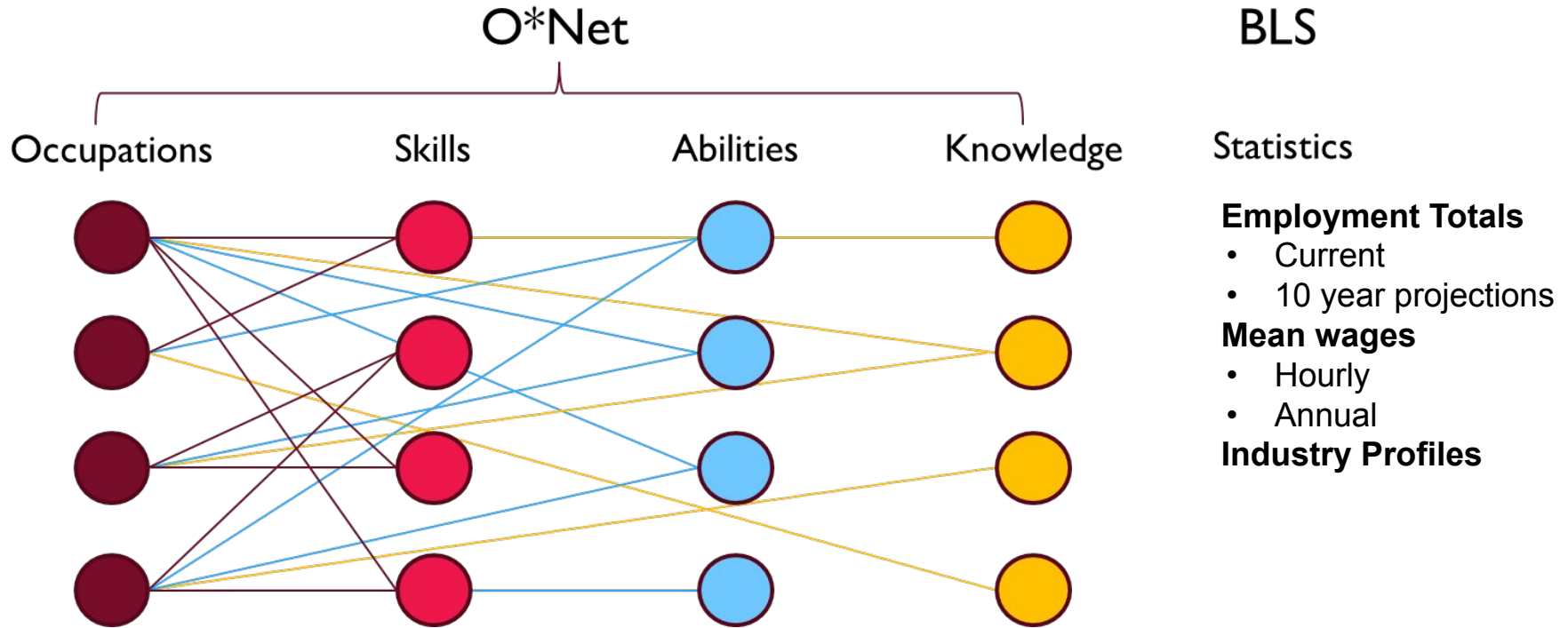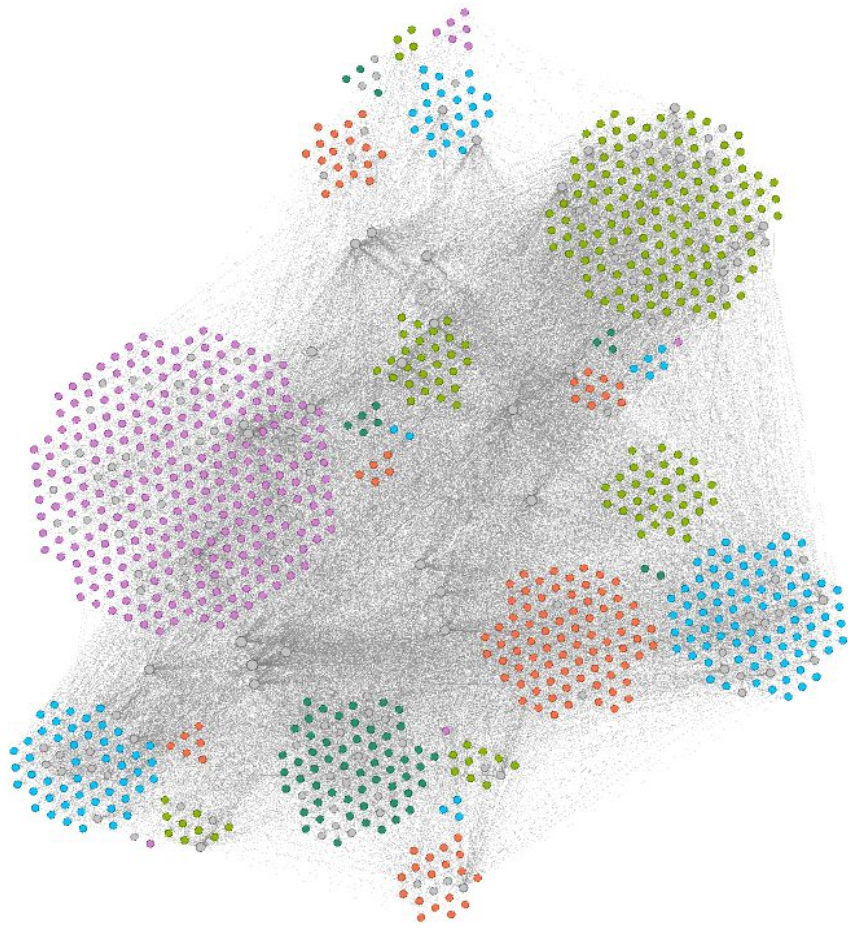- Employment Opportunity in Job listings

Visualization Plan

- Occupation and skills network maps
  - Interactions – filtering, zooming, details on demand
  - Map features updated based user's interests and values
    - Education, salary, risk scores, skill, etc.
  - Career pathway overlays
- Regional geospatial maps
  - Current and projected occupational employment
  - Educational opportunities
- Occupation profiles
  - Describe occupation in detail.
  - Similar occupations
  - Temporal trends for salary, occupation projects, risk

Occupation and skills network analysis

O*Net

BLS

Occupations   Skills   Abilities   Knowledge   Statistics

Employment Totals
- Current
- 10 year projections

Mean wages
- Hourly
- Annual

Industry Profiles

O*Net Occupation and Skills Network V 1.0

- Selected skill elements to use
- Tested layouts and clustering analysis methods
  - Blondel Community Detection Modularity Algorithm
  - Spin Glass Community Detection Algorithm
  - Filtered edges to include only high value weights
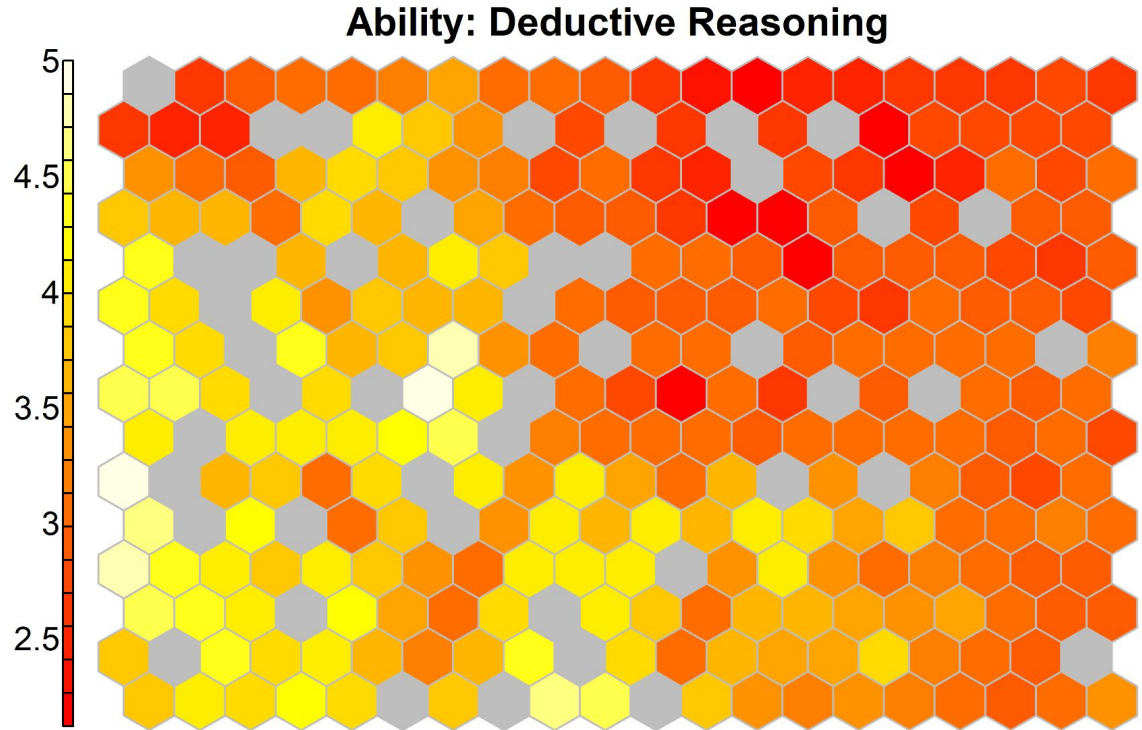
O*Net Occupation and Skills Network V 2.0

- Selected skill elements to use
- Tested layouts and clustering analysis methods
  - Blondel Community Detection Modularity Algorithm
  - Spin Glass Community Detection Algorithm
  - Filtered edges to include only high value weights
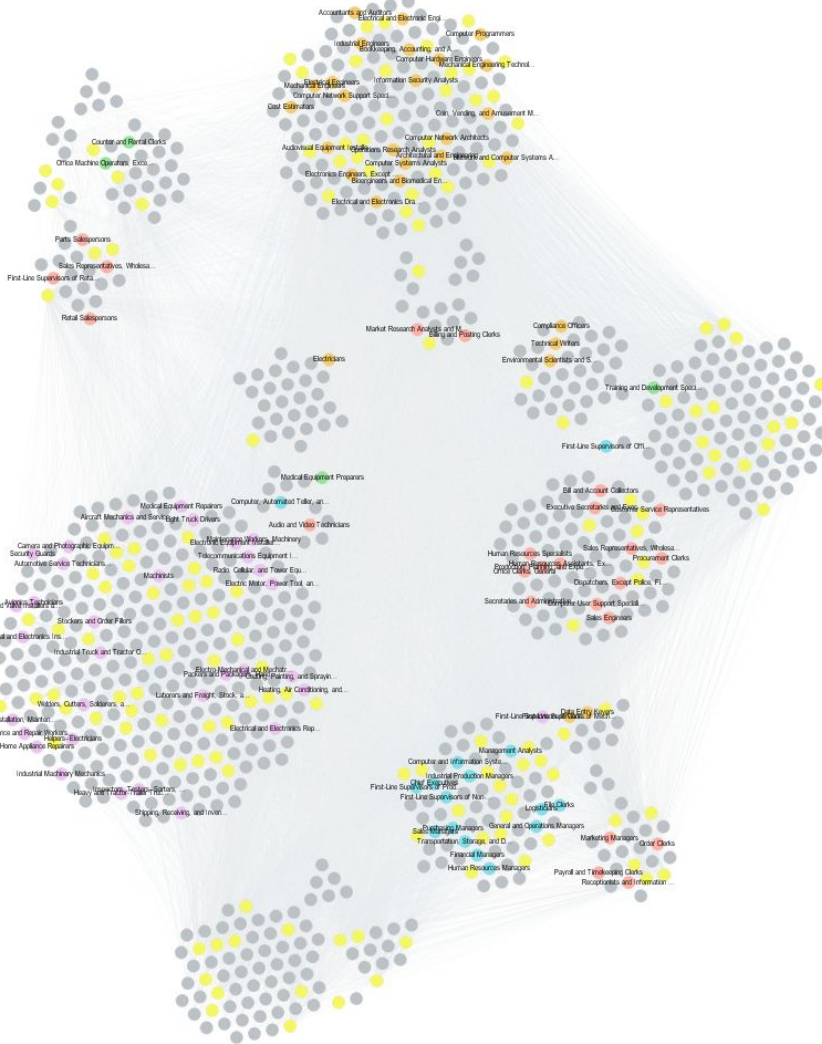
Self Organizing Map (SOM)

SOM was tested to build map using all of the O*Net data, i.e. maintain complexity of the skills data.

Results highlighted issues with inconsistent occupation-skills ratings in O*NET. The resulting maps had issues with legibility and interpretability.

Ability: Deductive Reasoning

O*Net Occ. and Skills Network v3.0

This version of the network relies on multistep process to generate the map layout.

1. Use circle pack algorithm to organize nodes based on the Blondel communities identified in the "knowledge" skills subgraph
2. Apply force atlas algorithm to each Blondel clusters with all skill elements.
3. Occupation nodes are fixed in place, and force atlas algorithm is re-applied to arrange skill elements among settle occupations.

The layout design accounts for the fact that occupations have broad overlap in their skills requirements, and that "Regional, industry maps" are needed supplement an overall map.

Occupation Skills Map:
Knowledge Elements

O*NETs Knowledge elements are dispersed throughout the network layout.

Knowledge elements are situated nearest/within the Blondel communities near occupations requiring this skill.

Using knowledge as the first level of organization helps analysts and viewers quickly characterize each occupation cluster in the map, and search for their interests.
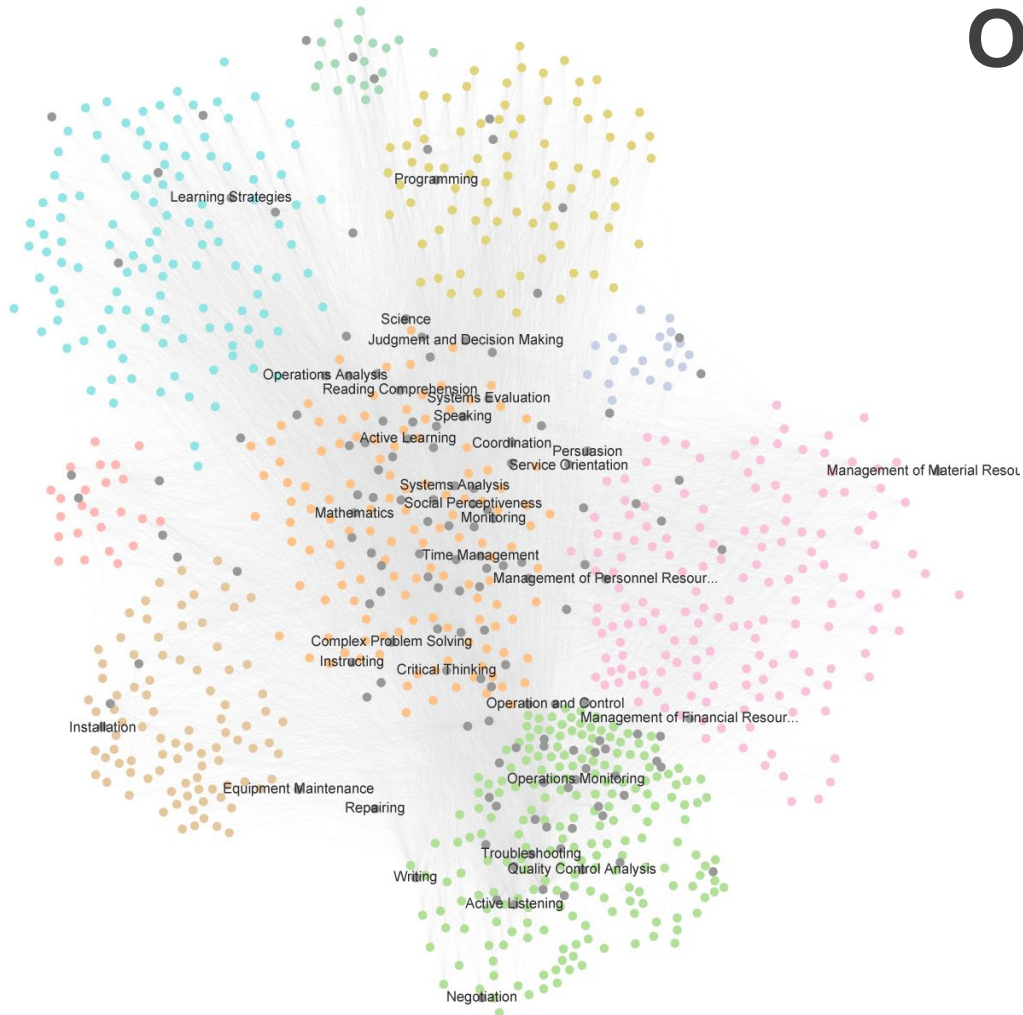
Occupation Skills Map:
Ability Elements

The remaining ONET element nodes tend to fall along a central axis within the network, which aligns to the knowledge elements used to organize the overall network

Spatial positions provided by the Force Atlas algorithm reveal insights about relationship between abilities, skills, and work activities and knowledge clusters.

- Specialization
  - Reasoning and expressing ideas
  - Memorization & peripheral vision
- Cognitive abilities vs physical abilities

Labels in figure: Memorization, Originality, Fluency of Ideas, Flexibility of Closure, Information Ordering, Inductive Reasoning, Written Comprehension, Deductive Reasoning, Number Facility, Mathematical Reasoning, Written Expression, Speech Clarity, Peripheral Vision, Time Sharing, Speed of Closure, Hearing Sensitivity, Category Flexibility, Near Vision, Visualization, Oral Expression, Spatial Orientation, Arm-Hand Steadiness, Gross Body Coordination, Perceptual Speed, Selective Attention, Visual Color Discrimination, Problem Sensitivity, Depth Perception, Stamina, Reaction Time, Far Vision, Finger Dexterity, Speech Recognition, Response Orientation, Multilimb Coordination, Auditory Attention, Trunk Strength, Extent Flexibility, Gross Body Equilibrium, Oral Comprehension, Dynamic Strength, Static Strength

Occupation Skills Map:
Skill Elements

Learning Strategies

Programming

Science

Judgment and Decision Making

Operations Analysis

Reading Comprehension

Systems Evaluation

Speaking

Active Learning

Coordination

Persuasion

Service Orientation

Management of Material Resou...

Systems Analysis

Mathematics

Social Perceptiveness

Monitoring

Time Management

Management of Personnel Resour...

Complex Problem Solving

Instructing

Critical Thinking

Operation and Control

Management of Financial Resour...

Installation

Operations Monitoring

Equipment Maintenance

Repairing

Writing

Troubleshooting

Quality Control Analysis

Active Listening

Negotiation

Occupation Skills Map:
Work Activity Elements

Occupational Cluster 5:
Science & Engineering

Occupations: 159 (19.16%)
Skill Elements: 124 (82.78%)

Edges: 3054 (18.82%)

This cluster includes most engineering, physics, chemistry, and computer science and analytics related occupations,

including technicians.
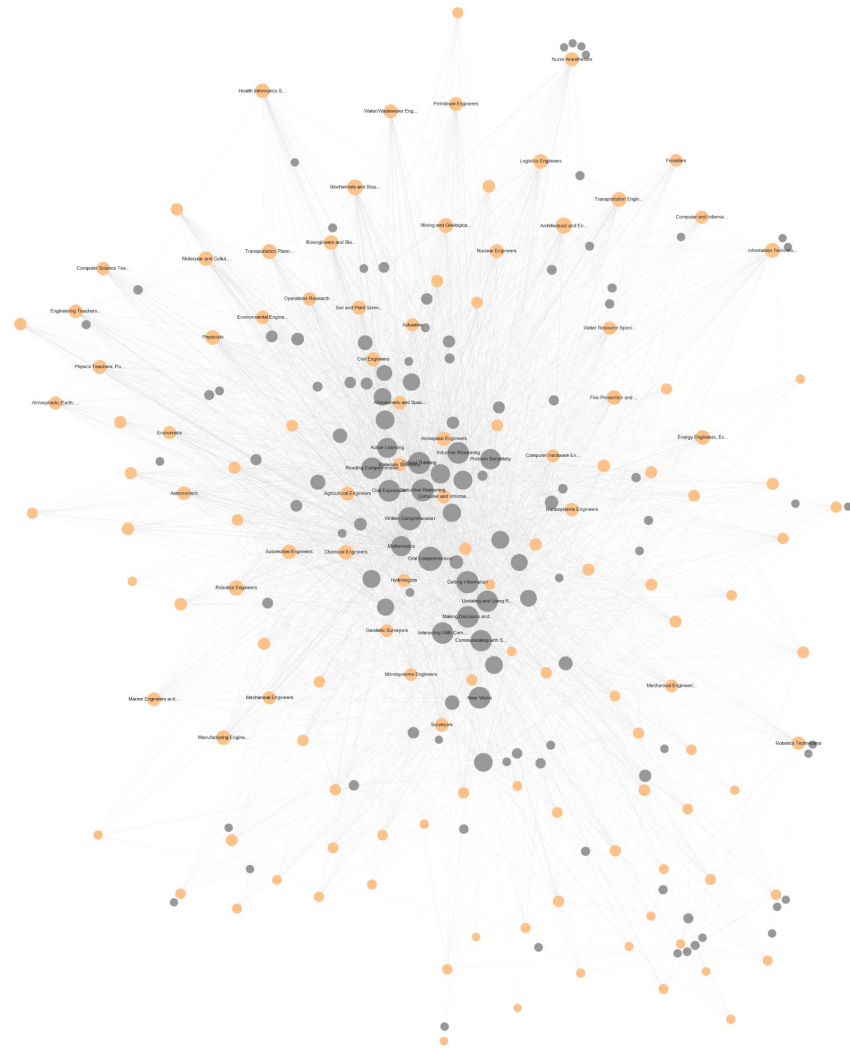
Occupational Cluster 1:

Customer Service, Sales/ Finance, & Managers

Occupations: 125 (15.18%)
Skill Elements: 112 (74.17%)

Edges: 3204 (19.74%)
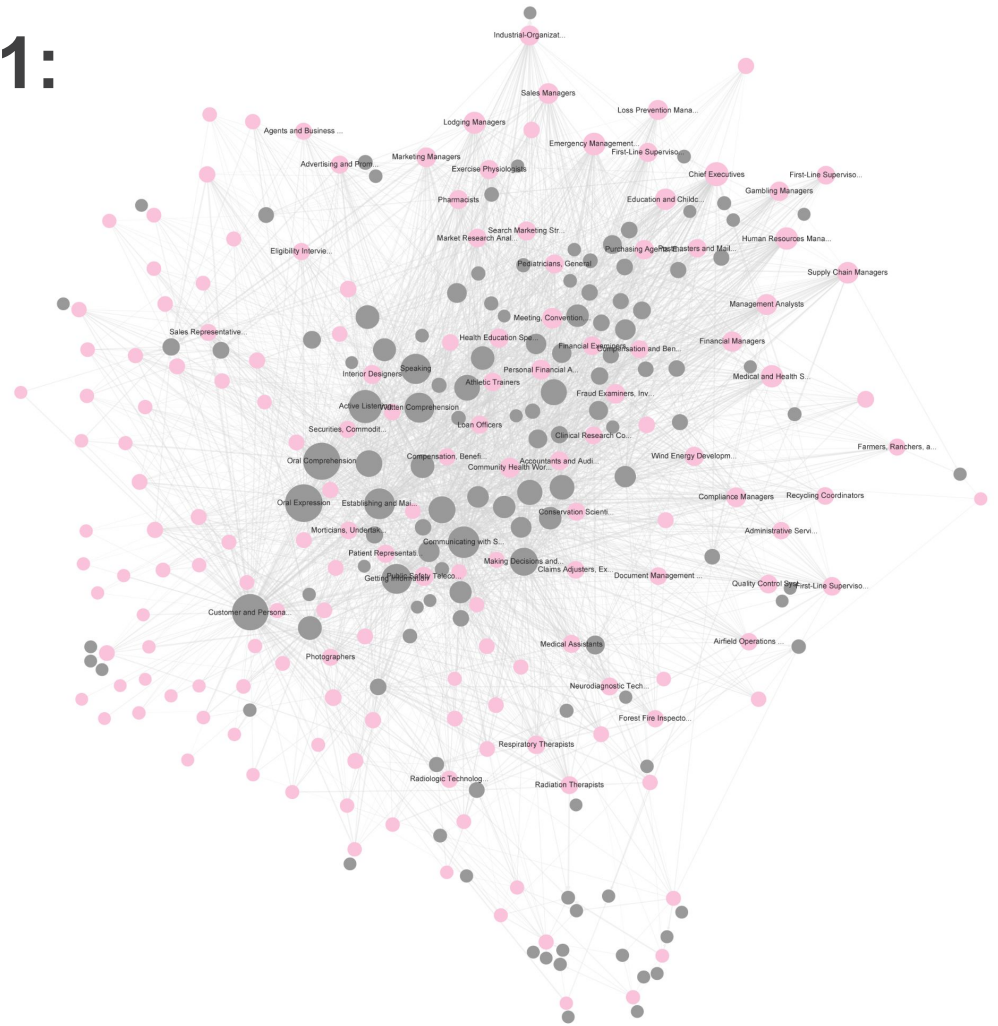
Occupational Cluster 8:
Low Knowledge Req.

Occupations: 196 (23.61%)
Skill Elements: 108 (71.51%)

Edges: 1617 (9.96%)

This cluster has no knowledge elements associated with occupations, and includes most manual labor and machine operators. However, some higher skill occupations are found here that may be better categorized with improved data and filtering.

OEWS 2020: Annual Wage
Mean annual wage for Engineers, All Other.

Mean Annual Wage ($)
100000
95000
90000
85000
80000

OEWS 2020: Annual Wage
Median annual wage for Engineers, All Other.

Median Annual Wage ($)
1e+05
9e+04
8e+04
7e+04
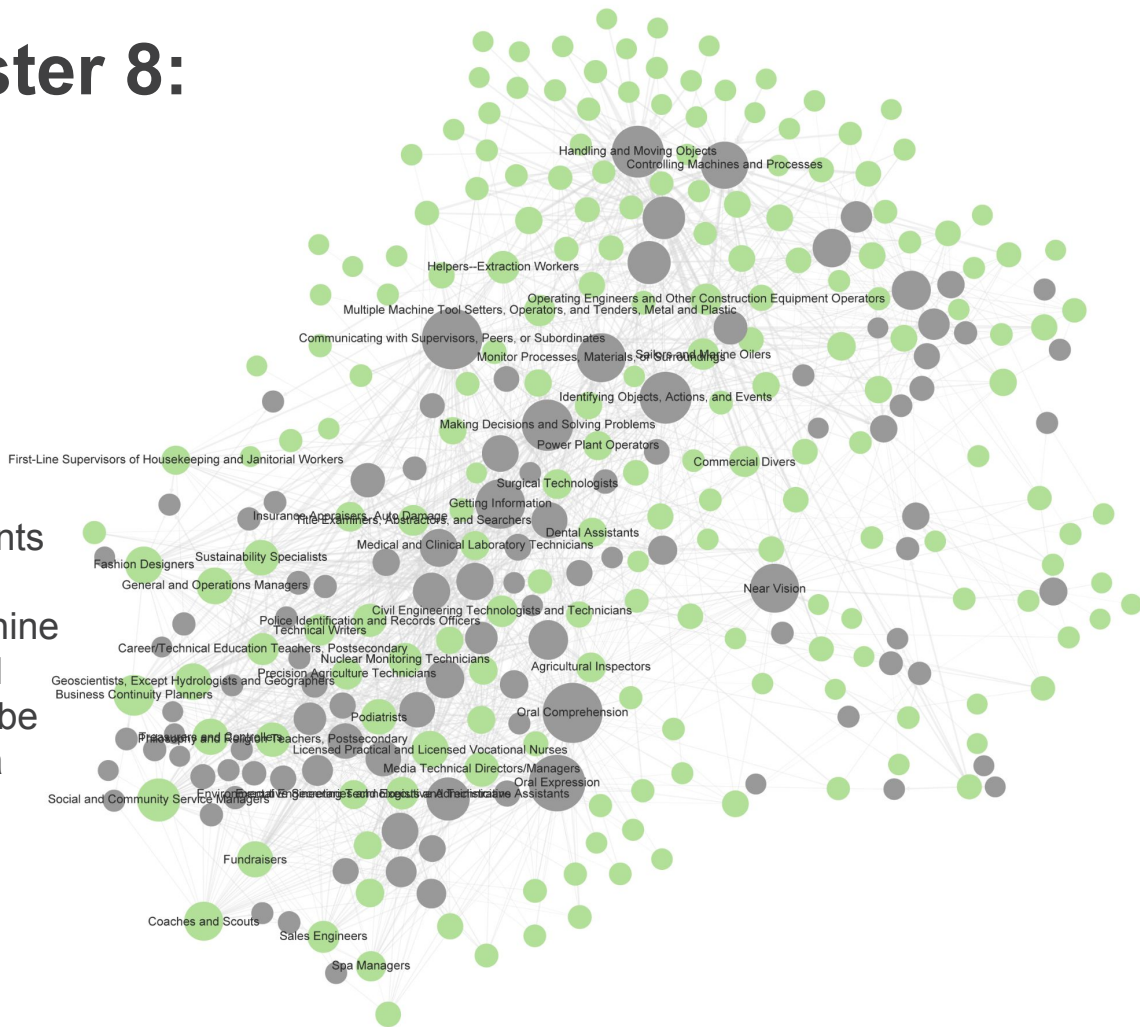
Mapping Microelectonics Occupations with OEWS Data
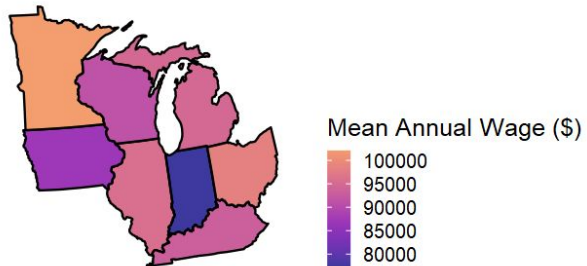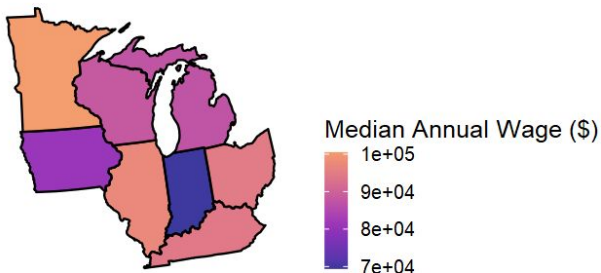
The US Bureau of Labor Statistics (BLS) releases annual Occupational Employment and Wage Statistics (OEWS) for major occupations tracked by the Dept. of Commerce.

OEWS are measured at US geopolitical units (e.g. states, metropolitan and rural census areas), which we can map!

We have implemented some example *choropleth maps* using OEWS data for select Microelectronics occupations found in O*NET for midwestern states.

Mapped OEWS measurements includes:

- total employment,

- 2 job concentration measures, and

- mean and median hourly and annual wages.

Computer Hardware Engineers

- Occupation found across much of the Midwest, with the greatest employment found in Ohio and Illinois
- However, the relative concentration of comp hardware engineers is greatest in Wisconsin.
- For figures on the right, the color scheme is mapped to the average salary (mean & median)
  - Highest salaries found in Illinois and Minnesota
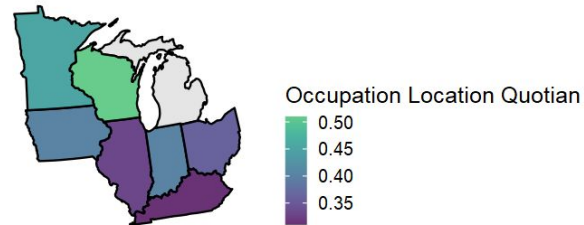 - Note: Salary is not measured equally in this data set.
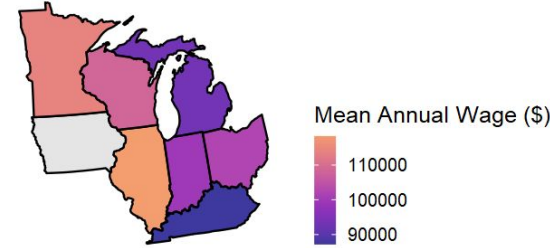

OEWS 2020: Total Employment
for Computer Hardware Engineers in the Midwest

Total Employment (except self-employed)
800
600
400
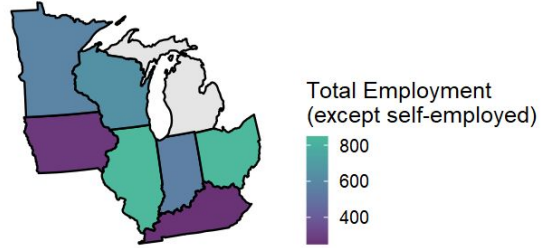
OEWS 2020: Jobs 1000
Number of employed Computer Hardware Engineers per 1,000 jobs.

Employed per 1,000 Jobs
0.22
0.20
0.18
0.16
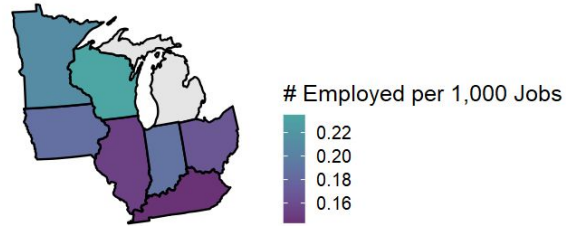
OEWS 2020: Location Quotiant
A ratio comparing Computer Hardware Engineers' state and national shares of employment.

Occupation Location Quotian
0.50
0.45
0.40
0.35

OEWS 2020: Annual Wage
Mean annual wage for Computer Hardware Engineers

Mean Annual Wage ($)
110000
100000
90000

OEWS 2020: Annual Wage
Median annual wage for Computer Hardware Engineers

Median Annual Wage ($)
110000
100000
90000
80000
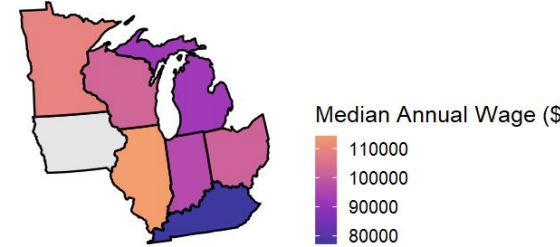
Aerospace Engineering & Operations Technologists and Technicians

- Limited presence in Midwest, with largest concentrations in Indiana and Ohio.
- The average salary range for this occupation is narrow, and so the color current color scale becomes too extreme.
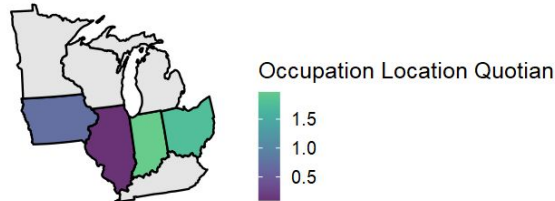 - Note salary is not measured equally in this data set.

OEWS 2020: Total Employment

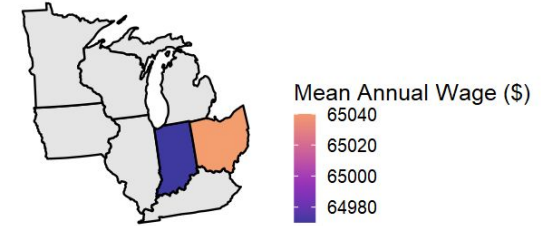for Aerospace Engineering and Operations Technologists and Technicians in the Midwest

Total Employment (except self-employed)

600
400
200
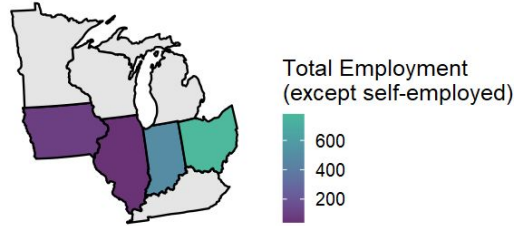
OEWS 2020: Jobs 1000

Number of employed Aerospace Engineering and Operations Technologists and Technicians per 1,000 jobs.

\# Employed per 1,000 Jobs

0.16
0.12
0.08
0.04
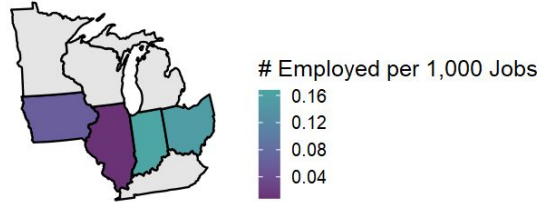
OEWS 2020: Location Quotiant

A ratio comparing Aerospace Engineering and Operations Technologists and Technicians' state and national shares of employment.


Occupation Location Quotian

1.5
1.0
0.5

OEWS 2020: Annual Wage

Mean annual wage for Aerospace Engineering and Operations Technologists and Technicians.

Mean Annual Wage ($)

65040
65020
65000
64980

OEWS 2020: Annual Wage

Median annual wage for Aerospace Engineering and Operations Technologists and Technicians.
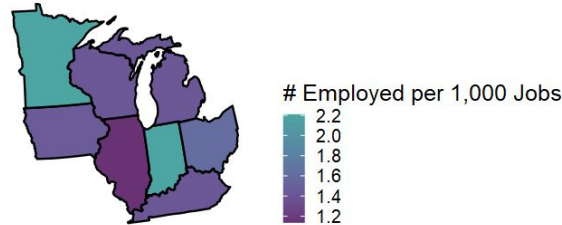

Median Annual Wage ($)

63500
63000
62500
62000
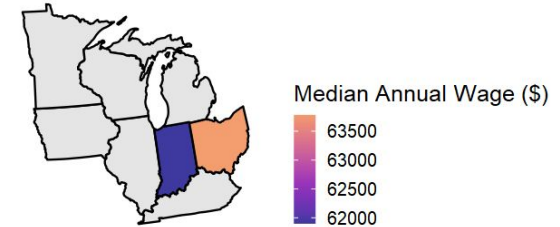
Sales Reps. for Technical and Scientific Products

- Occupation found across much of the Midwest, with the greatest employment found in Ohio, Indiana, Illinois, and Minnesota.

- Indiana and Minnesota have the highest concentration of technical and scientific products sales reps.

- Highest salaries found in Indiana and Michigan using a mean central tendency measure.

OEWS 2020: Total Employment
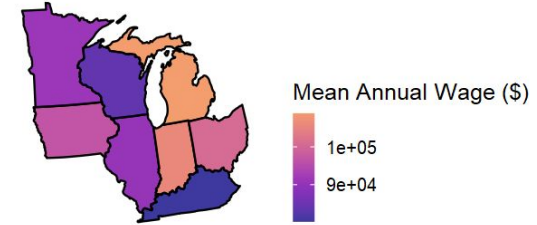for Sales Representatives... Technical and Scientific Products in the Midwest

Total Employment (except self-employed)
8000
6000
4000
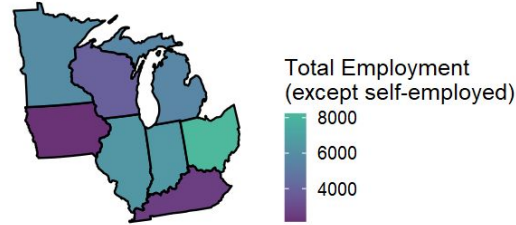
OEWS 2020: Jobs 1000
Number of employed Sales Representatives... Technical and Scientific Productsper 1,000 jobs.

Employed per 1,000 Jobs
2.2
2.0
1.8
1.6
1.4
1.2

OEWS 2020: Location Quotiant
A ratio comparing Sales Representatives... Technical and Scientific Products' state and national shares of employment.

Occupation Location Quotian
1.0
0.9
0.8
0.7
0.6
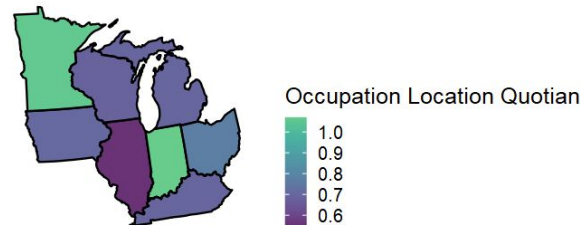
OEWS 2020: Annual Wage
Mean annual wage for Sales Representatives... Tech and Scientific Products.

Mean Annual Wage ($)
1e+05
9e+04

OEWS 2020: Annual Wage
Median annual wage for Sales Representatives... Tec and Scientific Products.

Median Annual Wage ($)
1e+05
9e+04
8e+04
7e+04
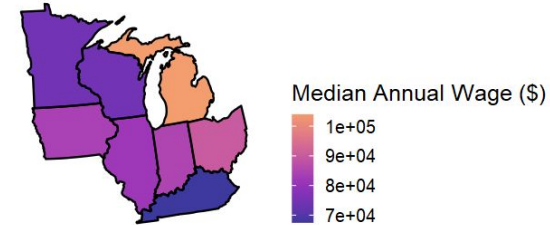
Future Development (2022 to 2024)

Y1.Q1 to Y2.Q2

- Implement a visual analytics **Occupation and Skills Map Dashboard** site,
  - Interactive versions of occupations and skills maps
    - Details on demand, filtering, and overlays
    - Visually represent risk scores, salaries, projections data on maps
  - Occupation profiles in three areas: microelectronics packaging, radiation hardening, and supply chain
  - Local employment data to help career coaches, hiring managers, and workforce entrants understand job market risks and opportunities.
- We will identify and engage career counselors and students in a user study to evaluate how stakeholders use these occupational skills maps and occupational profiles dashboard tools.