

Measuring skill needs with O*NET

Strengths, limitations, and alternatives

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Motivation

Job skill requirements—longstanding interest

1. Public policy concerns

- a. School-to-work transition, career guidance for students/youth
- b. Job counseling for unemployed and re-entrants
- c. Training sector—policy and practice
- d. Education sector interest in skills anticipation
- e. Assess national progress
- f. Possible mismatch between skill demand and supply (current or future)

2. Employers and workers' organizations

- a. Human resource planning
- b. Worker-member well-being, future preparedness

3. General public

- a. Left behind groups (urban poor, manufacturing/manual workers)
- b. Concerns over automation, AI, robotics (selective displacement)
- c. Anxiety over possible jobless future (mass unemployment)
- d. Public distress → political implications (populism, UBI)

Strong sense skills/jobs changing, but in what ways, how much, & how fast?

Occupation title leaves data gap—especially regarding trends; need scoring

Conceptual background

“Skill” means many different things in different contexts

Any capability that satisfies some technical requirement of some job

Covers a broad spectrum...

Common categorization: *cognitive, interpersonal, manual*

from Dictionary of Occupational Titles (1965, 1977), predecessor of O*NET

Schema

Cognitive

Reading, writing, basic math
Analytical, problem-solving
Common ICT skills
STEM
Other high-level knowledge
Mid-level knowledge
Detailed tasks (e.g., HTML, CNC, billing)

Interpersonal

Teamwork
Persuasion, negotiation
Leadership
Customer service
Communication, etiquette
Presentations
Job-specific (counseling, caring, selling)

Manual

Craft and repair skills
Knowledge of materials, tools, equipment
Strength and exertion

Bottom line

- **Clearly, skills are multi-dimensional and numerous**
- **They can be defined in broad categories or very detailed tasks**
- **Skills measurement instrument should cover as much as feasible**
- **No simple generalizations likely for detailed skills**
 - maybe some STEM skills in high demand, but not others
- **Measurement can be challenging**

O*NET (Occupational Information Network)

Occupational database online (<https://www.onetcenter.org>)

- mostly surveys completed by job-holders (<https://www.onetcenter.org/questionnaires.html>)
- random sampling through workplaces
- detailed information, multiple surveys
 - 277 occupational descriptors
 - 950 specific occupations
- frequent new features (e.g., Tools and Technology module)
- flags “Bright Outlook” occupations (fast-growing, many vacancies)
- intended for students, unemployed, other job-seekers
- sponsor: Employment and Training Administration, U.S. Department of Labor
(not a statistical agency)



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O*NET content

Strengths

- Education and training items
- Specific academic subjects and functional knowledge (e.g., biology, foreign language, mechanical knowledge)
- Problem solving demands
- Interpersonal skills
- Physical demands, stressors and hazardous working conditions

O*NET content

Limitations

- Technology-related skills
 - Level of complexity
 - Prevalence
- Organizational practices (e.g., layoffs, non-standard employment contracts)
- Overlapping, redundant content
- Many survey items too complex, poorly defined, and confusing (face validity)
- Response options often poorly constructed
- Occupational averages, not individual-level data

However...

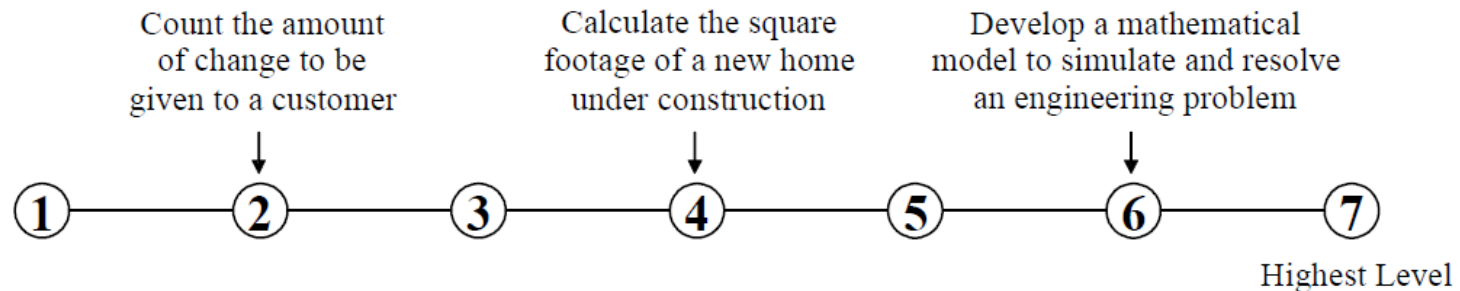
- Response rates appear high
- Many O*NET items correlate with wages (criterion validity)

More: “The O*NET Content Model: Strengths and Limitations,” Michael J. Handel,
[Journal for Labour Market Research](#) (2016)

5. Mathematics

Using mathematics to solve problems.

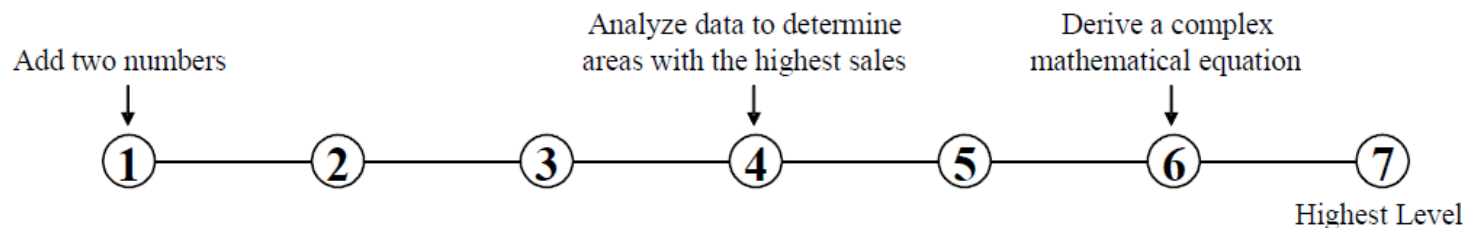
B. What level of MATHEMATICS is needed to perform *your current job*?



14. Mathematics

Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.

B. What level of knowledge of MATHEMATICS is needed to perform *your current job*?

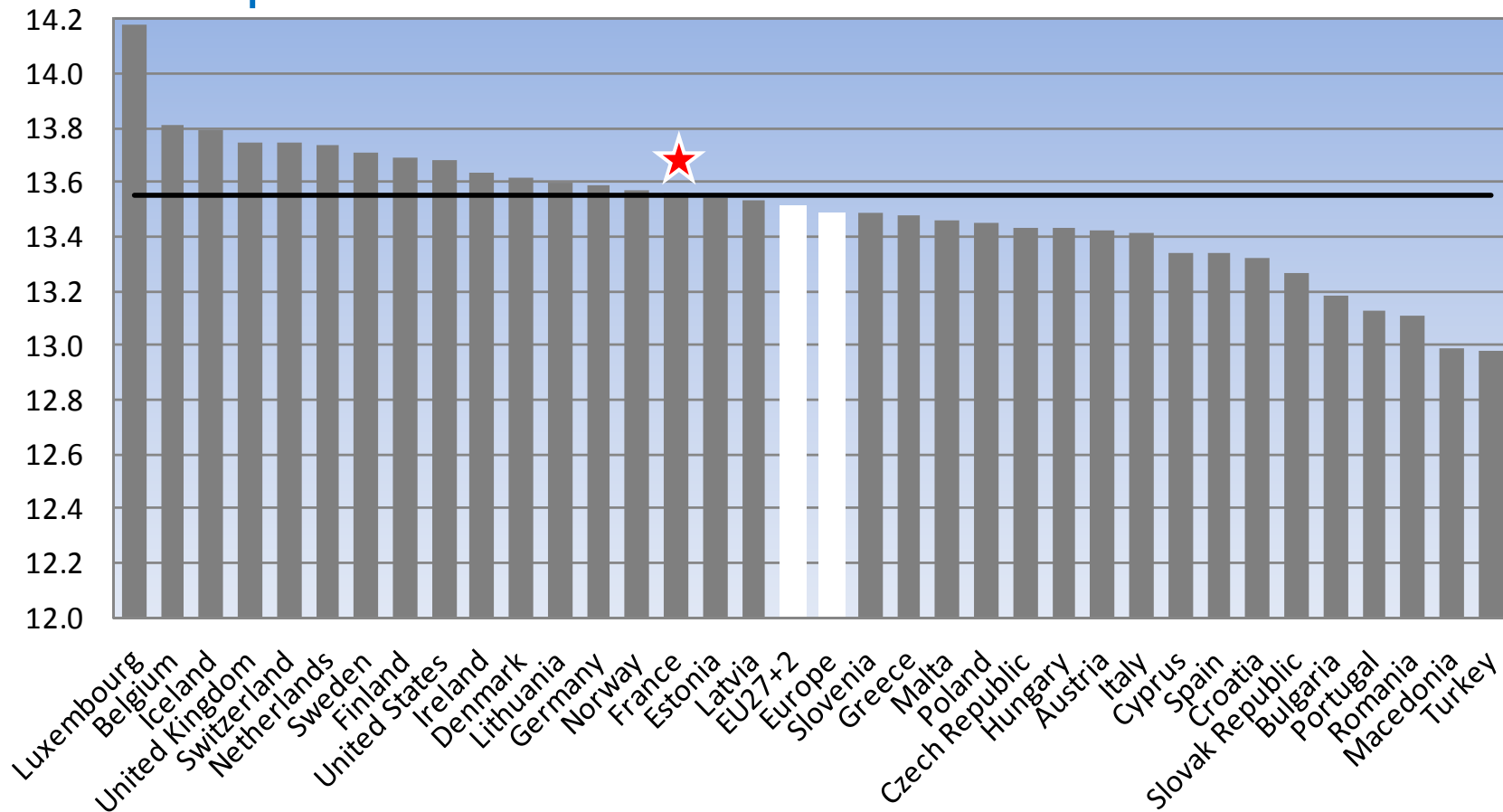


O*NET skill measures

1	Required education
2	Math requirements: (1) mathematics skills; (2) mathematics knowledge; (3) mathematical reasoning; (4) number facility ($\alpha=0.92$)
3	Verbal requirements: (1) reading comprehension; (2) writing skills; (3) writing comprehension; (4) writing ability; (5) knowledge of English language rules; (6) frequency of using written letters and memos ($\alpha=0.95$)
4	General cognitive demands: (1) analytical thinking; (2) critical thinking; (3) complex problem solving; (4) active learning; (5) analyzing data or information; (6) processing information; (7) thinking creatively; (8) updating and using relevant knowledge; (9) deductive reasoning; (10) inductive reasoning; (11) fluency of ideas; (12) category flexibility ($\alpha=0.97$)
5	People skills: (1) persuasion; (2) negotiation; (3) speaking skills; (4) frequency of face-to-face discussions; (5) frequency of public speaking; (6) communicating with persons outside organization; (7) dealing with external customers or public; (8) performing for or working directly with the public; (9) customer and personal service knowledge; (10) service orientation; (11) dealing with angry people; (12) dealing with physically aggressive people; (13) frequency of conflict situations; (14) resolving conflicts and negotiating with others; (15) instructing skills; (16) training and teaching others; (17) education and training knowledge; (18) interpreting the meaning of information for others; (19) social orientation; (20) social perceptiveness ($\alpha=0.94$)
6	Craft skills: (1) controlling machines and processes; (2) repairing and maintaining mechanical equipment; (3) repairing and maintaining electronic equipment; (4) equipment maintenance; (5) repairing machines; (6) troubleshooting operating errors; (7) installing equipment, machines, and wiring ($\alpha=0.95$)
7	Gross physical requirements: (1) handling and moving objects; (2) general physical activities; (3) static strength; (4) dynamic strength; (5) trunk strength; (6) stamina; and time spent (7) sitting, (8) standing, (9) walking, (10) twisting body, (11) kneeling, crouching, stooping, or crawling ($\alpha=0.98$)
8	Repetitive motions (time spent making repetitive motions)

Country averages n=35 (2009)

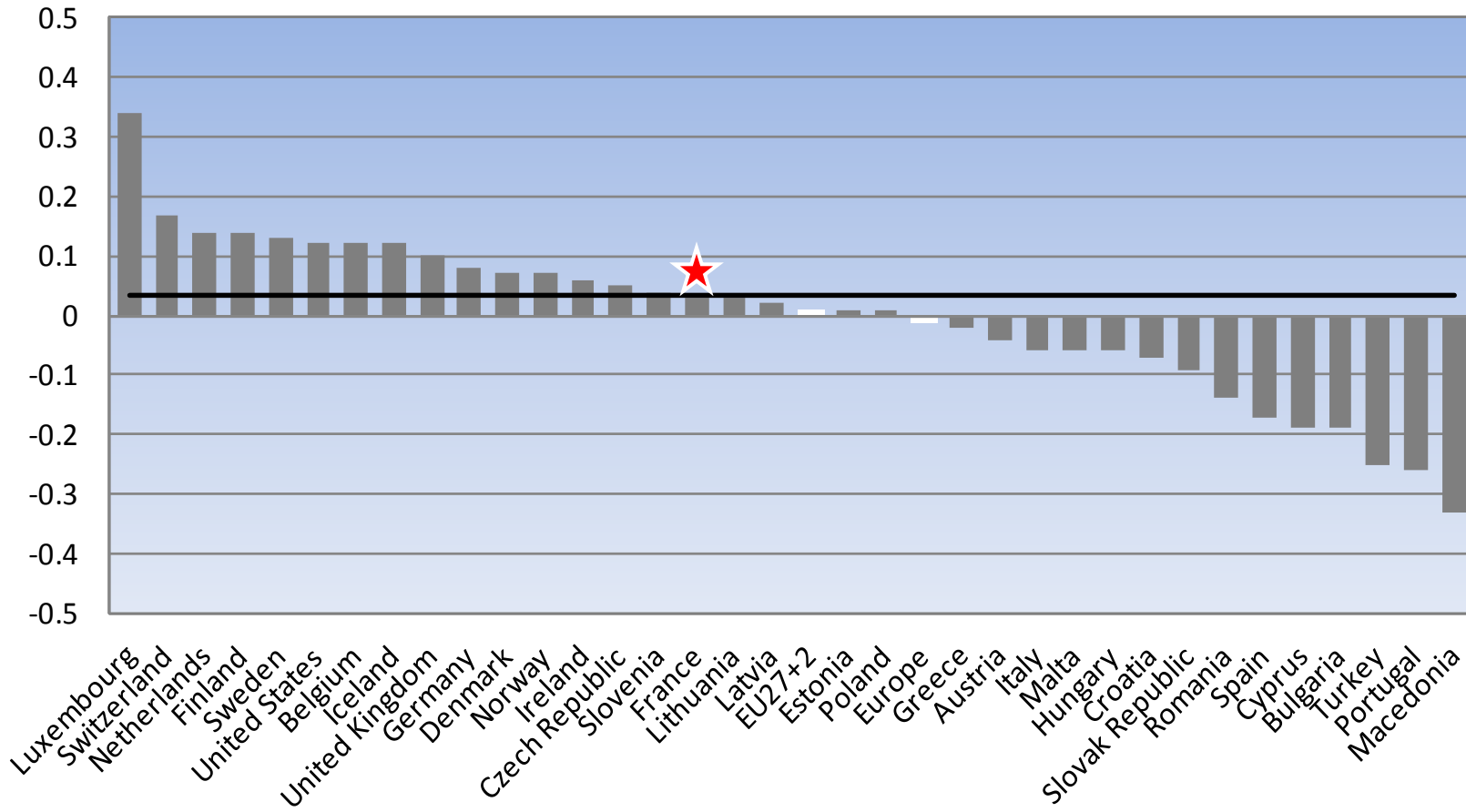
1. Required education



“Trends in Job Skill Demands in OECD Countries,” Michael J. Handel *OECD Social, Employment and Migration Working Papers* (No. 143). Paris: OECD

Country averages $n=35$ (2009)

2. General cognitive demands



O*NET trends across OECD

- Gradual changes for all 8 indicators across all countries (1997-2009)
 - all due to changing shares of broad (1-digit) occupations
 - skill composition within occupations remains constant
- ...but skills might be changing within detailed occupations (current project)
 - alternative data sources contradictory on this point

O*NET issues and alternatives

O*NET surveys have a number of problems

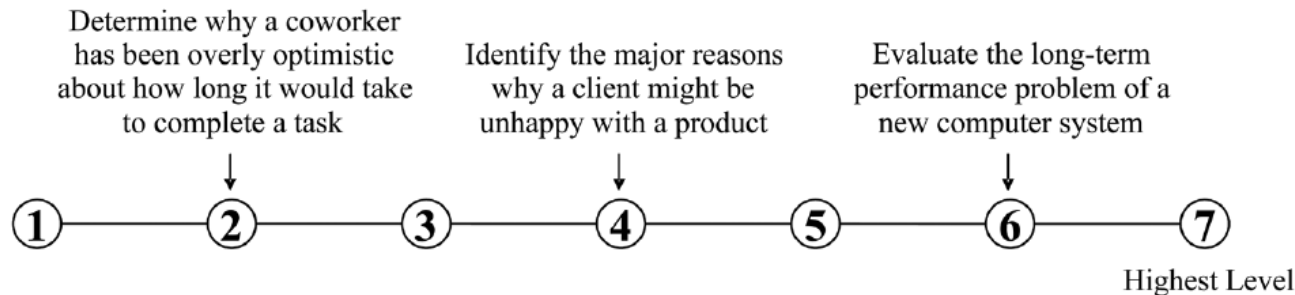
- Questions can be confusing
 - Overly complex
 - Jargon
 - Vague or compound constructs, not one idea per item
- Response options
 - Difficult to relate examples to own job
 - Equal interval assumption problematic
 - Extreme examples anchor Level 6 (ceiling effects)

30. Systems Evaluation

Identifying measures or indicators of system performance and the actions needed to improve or correct performance, relative to the goals of the system.

Questionable constructs

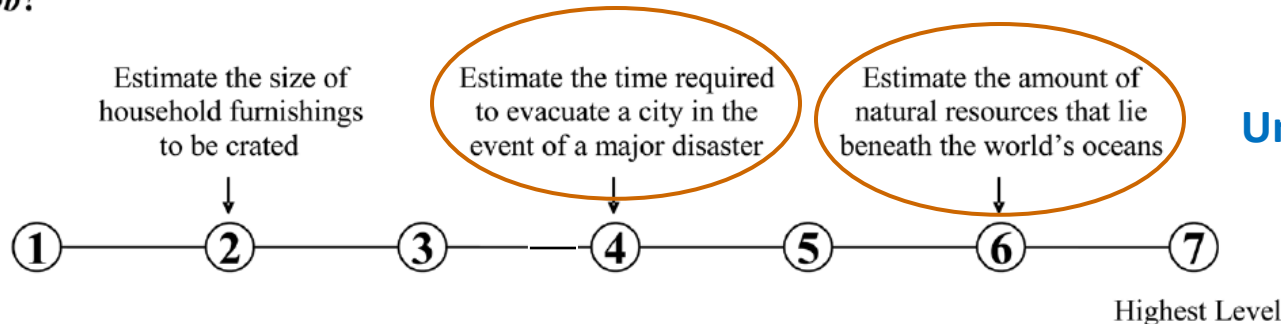
B. What level of SYSTEMS EVALUATION is needed to perform *your current job*?



5. Estimating the Quantifiable Characteristics of Products, Events, or Information

Estimating sizes, distances, and quantities; or determining time, costs, resources, or materials needed to perform a work activity.

B. What level of ESTIMATING THE QUANTIFIABLE CHARACTERISTICS OF PRODUCTS, EVENTS, OR INFORMATION is needed to perform *your current job*?



Unusual scale anchors

Enter Big Data—very recent

4. Burning Glass

- A. Big Data scraping of text from Help Wanted internet postings
- B. Very good coverage of job vacancies posted to internet—almost a census
 - 1) No coverage of vacancies not filled by postings, which varies by occ
 - 2) Are vacancies posts representative of current employment (inflow vs. stock)?
 - 3) Single posts can represent multiple vacancies (or no vacancy)
 - 4) Is it valid to assign skill scores from Help Wanted ads to occupation data in LFS?
 - 5) Algorithms for scraping and processing text evolve
 - Trend studies will need to distinguish real change from method changes (artifacts)
 - 6) BG ads corpus has little data on characteristics of workers hired to fill jobs
- C. Heroic effort to process text on skill demands into usable data
 - 1) Very new—still a work in progress
- D. Promising, but not clear all questions can be overcome
 - 1) **Probably will not completely substitute for survey-based data**

Alternative survey-based approach

Goal: Better data using standard household survey methods

- Feasible, easily replicable (cf. DOT, O*NET)
- Targets key constructs of interest
 - Skills (cognitive, interpersonal, physical), technology, work organization
- Widely usable
 - Internationally comparable
 - Can merge skill score averages by occupation to labor force data
- Contributes to data infrastructure, basic social indicators

Survey of Skills, Technology, and Management Practices (STAMP)

STAMP items included in OECD PIAAC project (38 countries) & World Bank STEP surveys (16 countries), and more specialized surveys (PDII, MIT's Production in the Innovation Economy project)

Survey of Skills, Technology, and Management Practices (STAMP)

- Two-wave, refreshed panel (N = 2,304, wave 1)
- Sample reinterviewed after 3 years, plus new subsample
- Nationally representative, RDD telephone survey
- Employed wage & salary workers, age ≥ 18
- English & Spanish language versions
- 166 job-specific questions, 28 mins. average length

STAMP Survey Content

Skill and Task Requirements

Cognitive skills

Math, reading, writing, document use

Problem-solving

Required education, experience, and learning times, training (captures occ-specific skills)

Interpersonal skills

Physical job demands

Supervision, Autonomy, Authority

Closeness of supervision, autonomy, repetitiveness

Supervisory responsibilities

Policy-making authority

Computer and Other Technology

Computers

Frequency of use

Use fourteen specific applications

Use advanced program features

Job-specific and new software

Training times

Complexity of computer skills required

Adequacy of respondents' computer skills

Computer experience of non-users in prior jobs

Machinery and electronic equipment

Set-up, maintenance, and repair

*Equipment and tool programming
(NC/CNC, robots, PLC)*

Mechanical and electronics knowledge

Employee Involvement

Job rotation, cross-training, pay for skill

Formal quality control program

Teams: *levels of activity, responsibilities, decision making authority*

Bonus and stock compensation

Job Downgrading

Downsizing, outsourcing, technological displacement

Promotion opportunity

Work load, pace, and stress

Pay and benefits cuts

Strike activity

Job Satisfaction

STAMP measurement approach

- **Explicit Scaling**

- **Items and response options**

- **Objective, behaviorally concrete questions**
 - **Facts, events, and behaviors**
- **Use natural units for measures rather than arbitrary metrics**
 - **Avoid rating scales, vague quantifiers, and PCA scores** (pure numbers)
- **External or ecological validity—verisimilitude**
- **Make items and scales readily interpretable & policy-relevant**
 - **Ideally linkable to education levels where relevant**

- **Not always feasible, but this is the goal**

More on validity and reliability: “Measuring Job Content: Skills, Technology, and Management Practices,” Michael J. Handel in [Oxford Handbook of Skills and Training](#), John Buchanan, et al., eds. Oxford: Oxford University Press (2017).

Impossibility of measuring “all” skills

Level of detail effectively infinite (“curse of dimensionality,” data reduction issue)

1. O*NET task data

- a. 19,450 “task statements” (occupation-specific, granular)
- b. Over 2,000 “Detailed Work Activities” (several occs within major group)
- c. 332 “Intermediate W.A.” & 41 “Generalized W.A.” (many occs across major groups)
- d. Rationale is identifying transferable skills, mobility paths for job switchers

2. Burning Glass task data

- a. ~16,000 task statements (just beginning to be used in research)
- b. Empirical, data-driven clustering (machine learning)

3. Occupational governance bodies (granular, occ-specific, qualitatively diverse)

- a. Nat’l Skill Standards Boards (U.S.), state voc education curricular standards
- b. UK Sector Skills Councils, German vocational standards
- c. Only a few transversal skills comparable across occs; specific skills are not

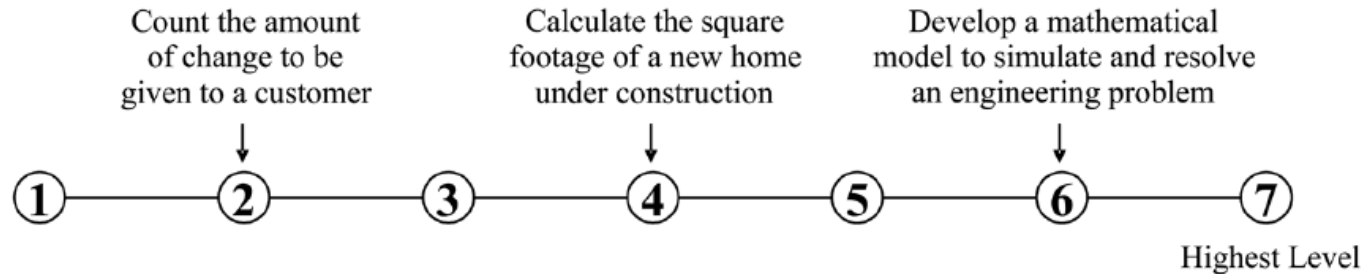
See also: *Know-How on the Job: The Important Working Knowledge of 'Unskilled Workers,'* by Ken C. Kusterer (1978)

O*NET math items (1)

5. Mathematics

Using mathematics to solve problems.

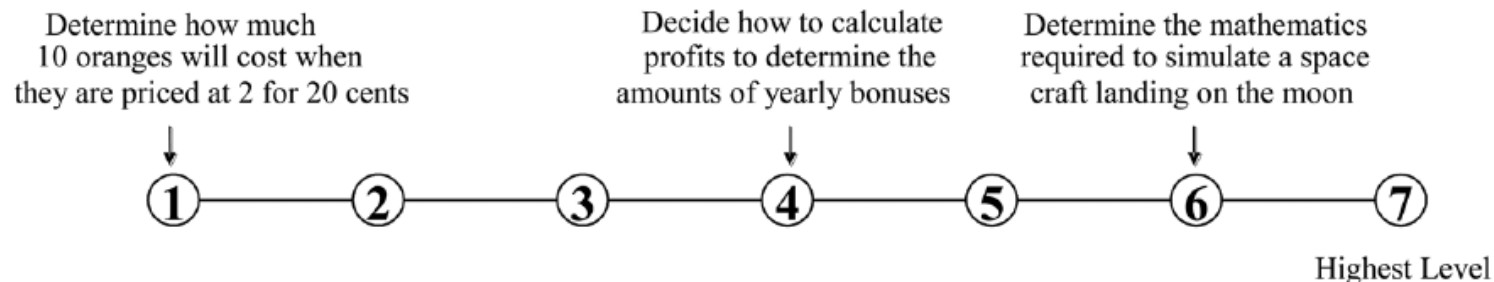
B. What level of MATHEMATICS is needed to perform *your current job*?



11. Mathematical Reasoning

The ability to choose the right mathematical methods or formulas to solve a problem.

B. What level of MATHEMATICAL REASONING is needed to perform *your current job*?

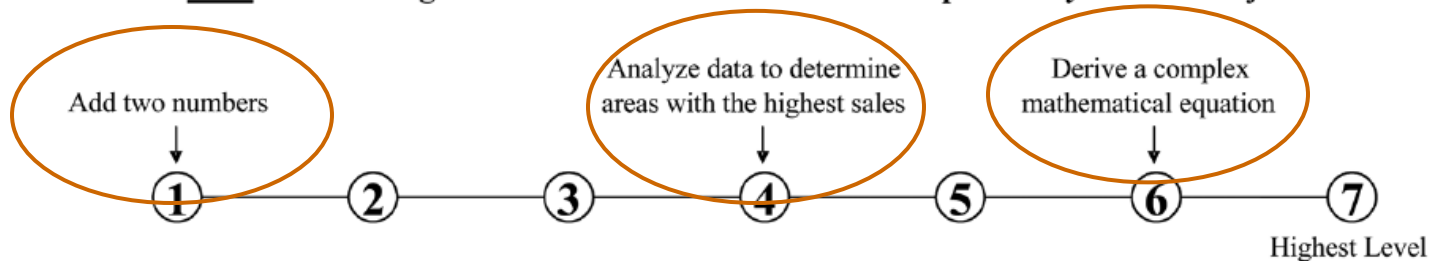


O*NET math items (2)

14. Mathematics

Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.

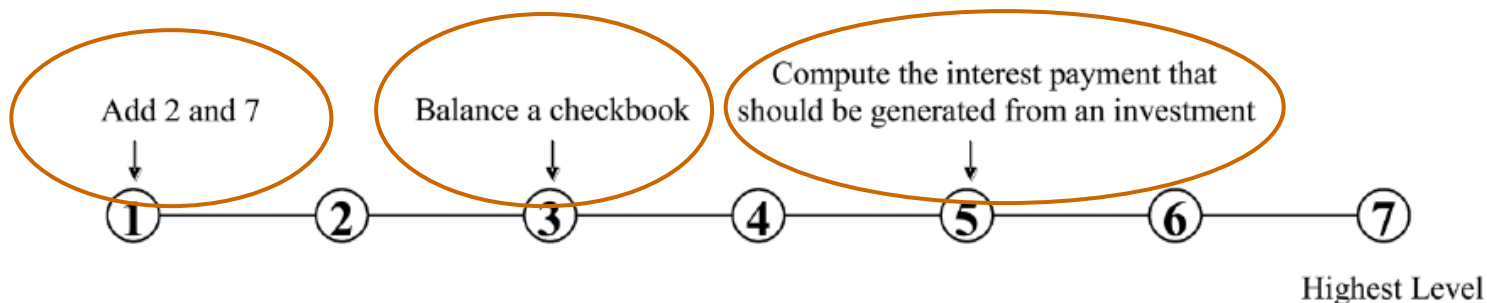
B. What level of knowledge of MATHEMATICS is needed to perform *your current job*?



13. Number Facility

The ability to add, subtract, multiply, or divide quickly and correctly.

B. What level of NUMBER FACILITY is needed to perform *your current job*?



STAMP math items

- **At your job, do you:**

- use addition or subtraction
- use multiplication or division
- do math using fractions, decimals, or percentages
- use simple algebra to solve for unknown values
- use more advanced algebra to solve complex equations
- use geometry or trigonometry
- use probability and statistics, such as correlations and regressions
- use calculus or other advanced mathematics

Easily linkable to education level

STAMP reading items

- **As part of your job, do you read:**
 - anything at work, even very short notes or instructions
 - articles or reports in trade magazines, newsletters, or newspapers
 - articles in scholarly, scientific publications, or professional journals
 - instruction manuals or other reference materials
 - work-related books
 - bills or invoices
- **Length of longest document normally read on job**
 - One page or less
 - 2 to 5 pages
 - 6 to 10 pages
 - 11 to 25 pages
 - More than 25 pages
 - Never read at job

Writing items very similar

Roughly linkable to education level

Math use at work

	All	Hi WC	Lo WC	Upper BC	Low BC	Service
Percentage (weight)	100	36.1	25.4	13	13.0	15.1
N (unweighted)	2,304	1,010	569	161	271	291
Math ($\alpha=81$)						
1. Any math	94	95	97	94	91	88
2. Add/subtract	86	93	90	87	78	73
3. Multiply/divide	78	89	82	81	65	57
4. Fractions	68	82	68	70	58	40
<i>Any more advanced</i>	22	35	9	41	19	4
5. Algebra (basic)	19	30	8	36	16	4
6. Geometry/trig	14	20	5	29	15	2
7. Statistics	11	22	5	10	6	2
8. Algebra (complex)	9	14	3	16	8	2
9. Calculus, et al.	5	8	1	8	5	1

Reading and writing at work

	All	Hi WC	Lo WC	Upper BC	Low BC	Service
Reading ($\alpha=80$)						
1. Any reading	96	99	97	91	91	95
2. One page	82	96	86	72	57	67
3. Five pages	54	81	47	46	26	32
4. News articles	42	64	37	27	21	24
5. Prof'l articles	38	65	26	24	15	23
6. Books	53	76	40	53	35	38
Writing ($\alpha=64$)						
1. Any writing	91	99	93	83	80	83
2. One page	61	86	56	46	36	41
3. Five pages	24	47	13	12	7	9
4. News articles	9	20	4	1	4	3
5. Books/prof'l arts	3	7	0	0	0	2

Computer use at work

	All	Hi WC	Lo WC	Hi BC	Lo BC	Service
Computers						
Data entry most of time	14	14	31	0	4	3
Spreadsheets	40	64	44	13	18	14
Spreadsheet macros, equations	12	21	11	2	6	3
Databases	19	32	20	7	7	3
SQL queries	3	8	1	1	1	1
CAD	7	10	5	5	6	2
Science/engineering tasks	7	14	3	4	4	2
Programming	4	8	2	0	1	1
Special software	47	61	59	23	29	24
New software in last 3 years	16	24	16	11	12	6
No. of applications (0-15)	4.02	6.06	4.68	1.68	1.91	1.41
Computer skill level ^a	4.21	5.91	5.06	1.95	2.43	1.77
Inadequate skills (users only)	23	26	18	30	23	22
Affected pay/promotion	8	3	5	10	18	13

Mechanical and other technology

	All	Hi WC	Lo WC	Hi BC	Lo BC	Service
Machine technology						
Heavy Machinery	20	7	11	65	46	12
Maintenance	10	3	1	41	21	10
Repair	8	3	1	35	16	7
Set-up	12	4	4	41	29	8
Machine tools	4	1	1	12	14	2
Use NC/CNC	2			3	9	
Program NC/CNC	1				6	
Industrial robots	1		1	2	3	
Program robots				1	1	
Programmable logic controller	2	1		6	4	
Computerized process control	4	3	2	14	12	
Program CPC	1	1		4	3	
Automated equipment	5	2	2	9	19	1
Assembly line	2		1	5	12	
New machinery in last 3 years	10	4	4	32	23	6
Training time >1 week	4	1	2	13	12	1
Mechanical Skill Level ^a	2.50	1.73	1.38	5.97	4.55	2.12
Electronics Skill	13	12	8	33	15	9

Downsizing, outsourcing, technological displacement

	All	Hi WC	Lo WC	Hi BC	Lo BC	Service
Δ employment in last 3 years						
<i>Lot less</i>	6	6	4	8	12	3
<i>A little less</i>	12	12	14	14	10	9
<i>About same</i>	50	48	47	52	47	60
<i>More</i>	33	35	35	25	12	29
Permanent layoffs	8	7	7	7	16	5
Outsourcing	4	3	3	5	13	2
Personally laid off, last 3 years	10	7	10	15	16	10
Replaced by machine	0				1	1
Ever on strike	3	2	2	8	7	2

Note: Blank cells have values less than 0.01