

# What Mathematics Do People Really Use in the Workplace?

Merrilea J. Mayo,  
Founder, Mayo Enterprises and  
Chief Information and Research Officer, Innovate+Educate

[merrilea\\_mayo@comcast.net](mailto:merrilea_mayo@comcast.net)

April 22, 2013

# There are tests for workplace mathematics, some quite good



**Table 24**

Correlations between WorkKeys® *Applied* Mathematics Level Scores and Job Performance Ratings

| Study | Sample Size | Correlation |
|-------|-------------|-------------|
| 1     | 142         | 0.41        |
| 2     | 27          | 0.41        |
| 3     | 24          | 0.41        |
| 4     | 141         | 0.41        |
| 5     | 56          | 0.34        |
| 6     | 120         | 0.23        |

ACT has profiled over 16,000 jobs and designed this test to match the math needed in over 90% of those jobs.

# Cognitive skills tests in general are much better at predicting who will be “successful on the job” than a degree does



| Predictor                             | Validity |           | No. of studies | Total subjects |
|---------------------------------------|----------|-----------|----------------|----------------|
|                                       | <i>M</i> | <i>SD</i> |                |                |
| Hunter and Hunter (1984) <sup>a</sup> |          |           |                |                |
| Ability composite                     | .53      | .15       | 425            | 32,124         |
| Job tryout                            | .44      | —         | 20             | —              |
| Biographical inventory                | .37      | .10       | 1              | 4,429          |
| Reference check                       | .26      | .09       | 10             | 5,389          |
| Experience                            | .18      | —         | 425            | 32,124         |
| Interview                             | .14      | .05       | 10             | 2,694          |
| Training and experience ratings       | .13      | —         | 65             | —              |
| Academic achievement                  | .11      | .00       | 11             | 1,089          |
| !!! Education                         | .10      | —         | 425            | 32,124         |
| Interest                              | .10      | .11       | 3              | 1,789          |
| Age                                   | -.01     | —         | 425            | 32,124         |

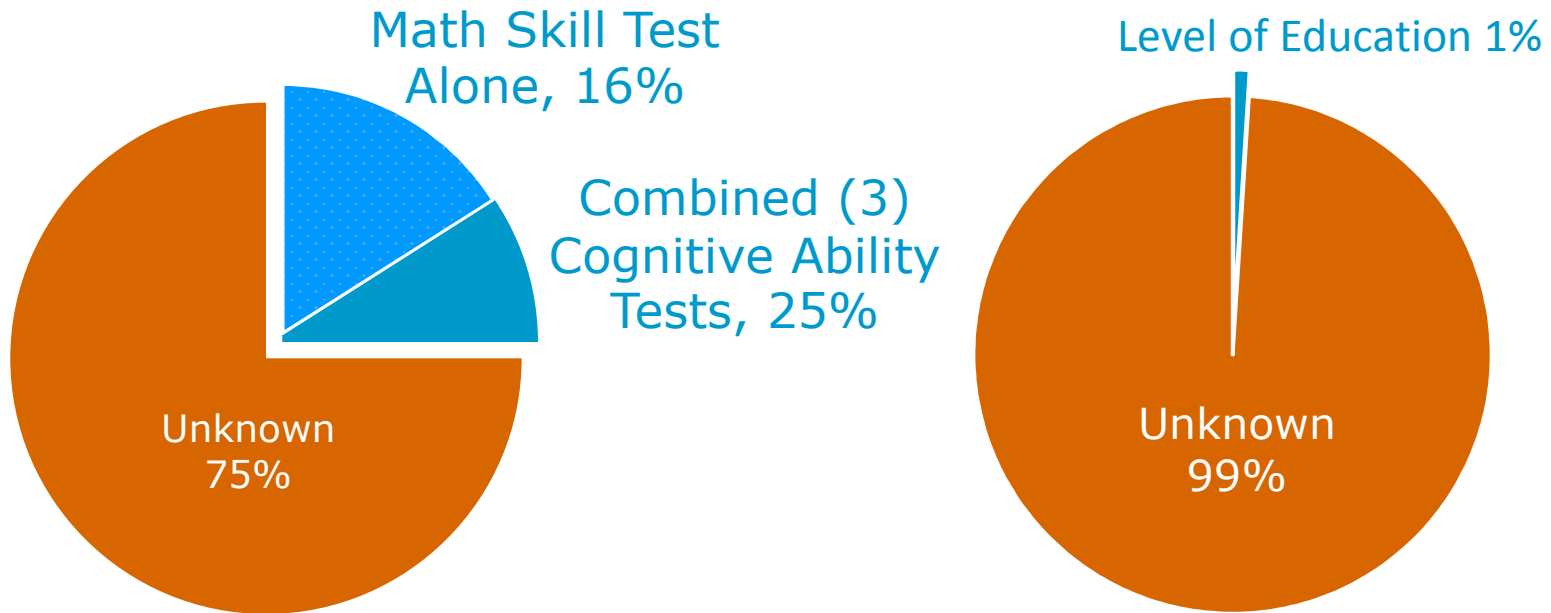
Ability Composite = measurement of 3 cognitive skills, strongest predictor of on-the-job performance

WorkKeys Math Test = 1 cognitive skill, little less strong predictor

Reference: J.E. Hunter and R.F. Hunter, “Validity and Utility of Alternate Predictors of Job Performance,” *Psych Bull* 96, 72-98 (1984).

# Another way of looking at the numbers

## VARIATION IN INDIVIDUALS' ON-THE-JOB PERFORMANCE IS SUCCESSFULLY EXPLAINED BY:



These numbers are the prior validity numbers, squared.

# Skills (Ability Composite) tests predict performance on complex jobs better than simple jobs

| <b>JOB COMPLEXITY</b><br><small>(as determined from DOL's "data" dimension in its Dictionary of Occupational Titles)</small> | <b>HOW WELL SKILLS TESTING PREDICTS PERFORMANCE (RAW VALIDITY)</b><br><br><small>1 = perfect prediction of performance<br/>0 = zero ability to predict performance</small> |
|--|--|
| High Complexity  | .58  |
| Medium Complexity  | .51  |
| Low Complexity   | .40  |
| Unskilled  | .23  |

# Literature supporting validity of .3 to .6 for cognitive skill tests' prediction of job performance

Literally over  
1,000 studies,  
over 40 years and  
many job types.

- M.M. Olea and M.J. Ree, *J. Appl. Psych* 79, 845-851 (1994).
- M.H. Ree, J.A. Earles and M. Teachout, *J. Appl. Psych* 79, 518-524 (1994).
- K. Brown, H. Le and F.L. Schmidt, *Intl. J. Selection and Assessment* 14, 87-100 (2006).
- Schmidt, Ones, and Hunter, *Ann. Review Psych* 43, 627-70 (1992).
- J.E. Hunter and R.F. Hunter, *Psych Bull* 96, 72-98 (1984) Also: a full decade of papers by Hunter from 1980-1990, covering an enormous number of datasets.
- K. Pearlman, F.L. Schmidt and J.E. Hunter, *J. Appl. Psych* 65, 373-406 (1980).
- F.L. Schmidt, J.E. Hunter, and J.R. Caplan, *J. Appl. Psych* 66, 261-273 (1981).
- L.C. Northrup, *Validity Generalization Results for Apprentice and Helper-Trainer Positions*. Washington, DC: U.S. Office of Personnel Management, Office of Staffing Policy (1986).
- J.A. Hartigan and A.K. Wigdor, *Fairness in Employment Testing: Validity Generalization, Minority Issues, and the General Aptitude Test Battery*. Washington, DC: National Academy of Sciences (1989).
- E.E. Ghiselli, *The Validity of Occupational Aptitude Tests*. New York: Wiley, 1966. (1966), Also: E.E. Ghiselli, *Personnel Psych.* 26 461-477. (1973).
- J.F. Salgado, H. Anderson, S. Moscoso, C. Berta and F. De Fruyt, *Personnel Psych* 56, 573-605 (2003).
- H.R. Hirsch, L.C. Northrup, and F.L. Schmidt, *Personnel Psych* 39, 399-420 (1986).
- M.H. Trattner, *The Validity of Aptitude and Ability Tests for Semiprofessional Occupations Using the Schmidt-Hunter Interactive Validity Generalization Procedures*. Washington, DC: U.S. Office of Personnel Management, Office of Staffing Policy (1988).

# When used in hiring, cognitive skills tests deliver real-world results

| EMPLOYER   | POSITIONS FILLED<br>(Using WorkKeys®)  | OUTCOMES<br>(compared to prior practices)  |
|--|--|--|
| BERNER FOOD AND BEVERAGE<br>(Dakota, IL)                 | Food production.   | <b>95% REDUCTION</b> in worker's compensation.<br><b>80% REDUCTION</b> in cost of nonconforming product.<br>Longest run to date without a lost-time injury. Turnover now down to 2%. |
| FARMINGTON PUBLIC LIBRARY<br>(Farmington, NM)            | Library clerk.   | Cost-to-hire <b>REDUCED 70%</b> ; time-to-hire <b>REDUCED 60%</b> .<br>applicant pool <b>TRIMMED BY 78%</b> .  |
| BUCKMAN REGIONAL WATER TREATMENT PLANT<br>(Santa Fe, NM) | All positions within the company.  | 0 turnover after one year.   |
| PGT INDUSTRIES<br>(Salisbury, NC and Venice, FL)         | Manufacturing, glass processing, and logistics.                                | <b>30% REDUCTION</b> in turnover; <b>50% REDUCTION</b> in training costs; <b>50% REDUCTION</b> in training time.   |
| ENERGIZER<br>(Dakota, IL)                                | Production operators, electricians, equipment mechanics, anode room operators. | Skills-related <b>TURNOVER IS NOW 0.</b>   |
| CG POWER SYSTEMS<br>(Dakota, IL)                         | 17 different positions.  | <b>TURNOVER &lt;3%</b>   |



# When used in hiring, cognitive skills tests deliver real world results

## EMPLOYER

## OUTCOMES (compared to prior practices)

SUBARU AUTOMOTIVE

25% **REDUCTION** in turnover.

COVIDIAN HEALTH  
CARE

**28 DAYS SAVED** in time-to-hire. **\$1,700 SAVINGS** in hiring cost per person. **1.5 YEARS** saved in time-to-full employee efficiency.

STEELSCAPE

<4% **OVERALL** turnover.

INOVA HEALTH SYSTEM

**73% REDUCTION** in turnover; **\$1.8 MILLION** cost savings.

BRADNER VILLAGE,  
A RETIREMENT  
COMMUNITY

37% **DOWN** in turnover.

911 CALL CENTER

**53% REDUCTION** in turnover; **0%** skills-related turnover.



New Options  
NEW MEXICO

Powered by  
www.newoptions.com



So We Have A Test of Workplace Math  
that Accurately Predicts Workplace  
Performance.

How Is It Different from  
“School Math”?



# Content is different

## Math Through 6<sup>th</sup> Grade Only.

### **INCLUDED**

- Addition, subtraction, multiplication, division (these operations for negative numbers as well), fractions, decimals, percentages, mixed numbers, unit conversions, averages & other simple statistics, ratios, rates, order of operations, perimeters, areas, volumes.

### **NOT INCLUDED**

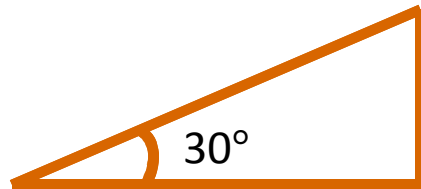
- Trigonometry, Pre-Calculus, Calculus. Algebra is not explicitly included but is useful for problems involving more complex order-of-operations.



## Context is different

- All problems are highly plausible “on-the-job” situations.
- None of the problems has explicit math.
  - No “find the common denominator.”
  - No written formulas you are told to rearrange or solve.
  - YOU must interpret the English in terms of math and YOU must choose the correct math tools to solve the problem.
- All problems are “word problems.”

# Scoring scheme is different



$$2+2=?$$

A. What is the sin of 30?

B. What is the sum of 2+2?

- School Math View: Problem A is harder than Problem B because A is trigonometry (taught in 9th grade) and B is arithmetic (taught in 2nd grade).
- Workplace Math View: Problem A and Problem B are the same. Both require simple memorization of a fact. There is no way to solve either problem using reasoning or deduction. Thus, both questions measure math skill at a sub-literate level.

## In tests of workplace math skill, higher-level questions have the following features:

- More and more extraneous information to sort through.
- More and more rearranging of information required to get to the answer.
- More and more chained steps. Sequencing is important.

**IN SUM:** Workplace Math is “critical thinking,” as applied to math.



## Applied Mathematics Level 3

# (Qualified for entry-level job)

### SAMPLE ITEM:\*

In your job as a cashier, a customer gives you a \$20 bill to pay for a can of coffee that costs \$3.84. How much change should you give back?

- A. \$15.26
- B. \$16.16
- C. \$16.26
- D. \$16.84
- E. \$17.16

## Applied Mathematics Level 5

# (Qualified for skilled labor or college)



### SAMPLE ITEM:\*

Quick Call charges 18 cents per minute for long-distance calls. Econo Phone totals your phone usage each month and rounds the number of minutes up to the nearest 15 minutes. It then charges \$7.90 per hour of phone usage, dividing this into 15-minute segments if you use less than a full hour. If your office makes 5 hours 3 minutes worth of calls this month using the company with the lower price, how much will these calls cost?

- A. \$39.50
- B. \$41.48
- C. \$41.87
- D. \$54.00

\*From WorkKeys<sup>®</sup> Applied Mathematics Test, Level 5. WorkKeys is a registered trademark of ACT, Inc. For more information please visit <http://www.act.org/products/workforce-act-workkeys/>

Applied Mathematics Level 7

# (Qualified for professional level work)



## SAMPLE ITEM:\*

The farm where you just started working has a vertical cylindrical oil tank that is 2.5 feet across on the inside. The depth of the oil in the tank is 2 feet. If 1 cubic foot of space holds 7.48 gallons, about how many gallons of oil are left in the tank?

- A. 37
- B. 59
- C. 73
- D. 230
- E. 294

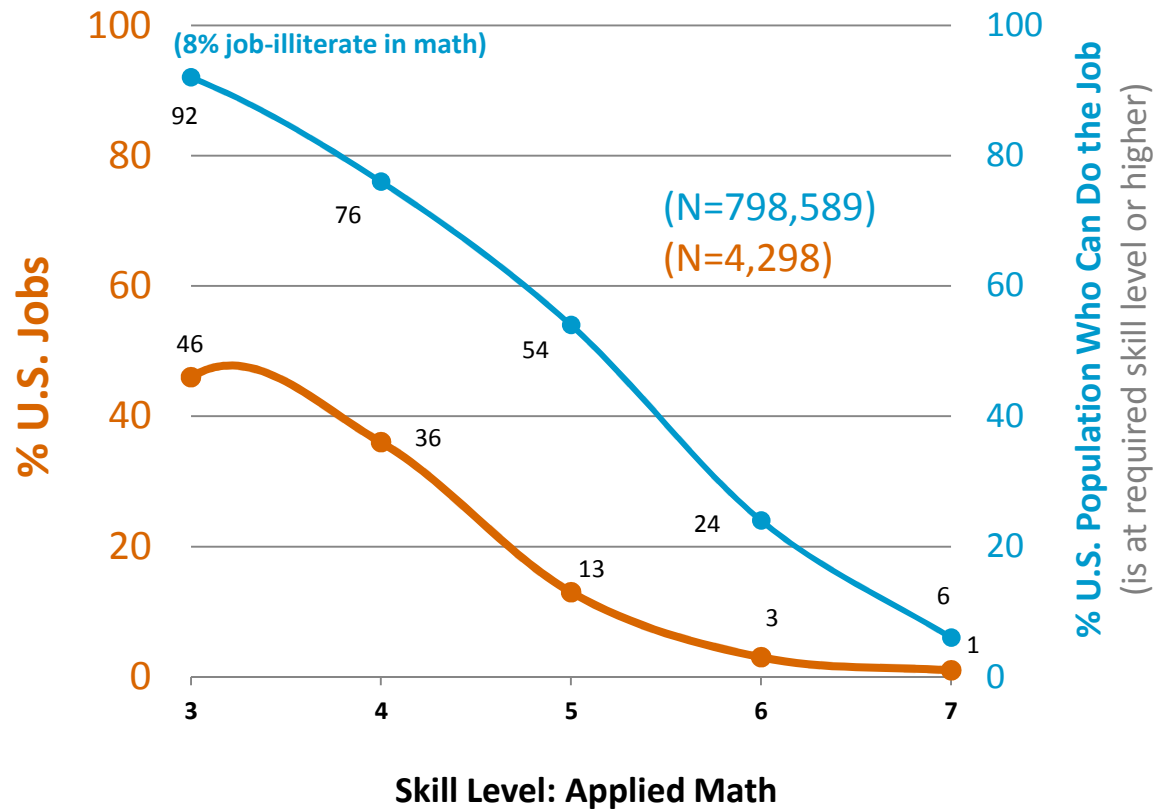
\*From WorkKeys<sup>®</sup> Applied Mathematics Test, Level 7. WorkKeys is a registered trademark of ACT, Inc. For more information please visit <http://www.act.org/products/workforce-act-workkeys/>



If We Measure the U.S. Population Against U.S.  
Jobs in Terms of Workplace Math  
Requirements, What Do We Find?

# (Un)fortunately For The U.S., Most U.S. Jobs Don't Require Much Math

## WorkKeys® APPLIED MATH



# However, some important jobs do (List Of Occupations Requiring AM Level 7)

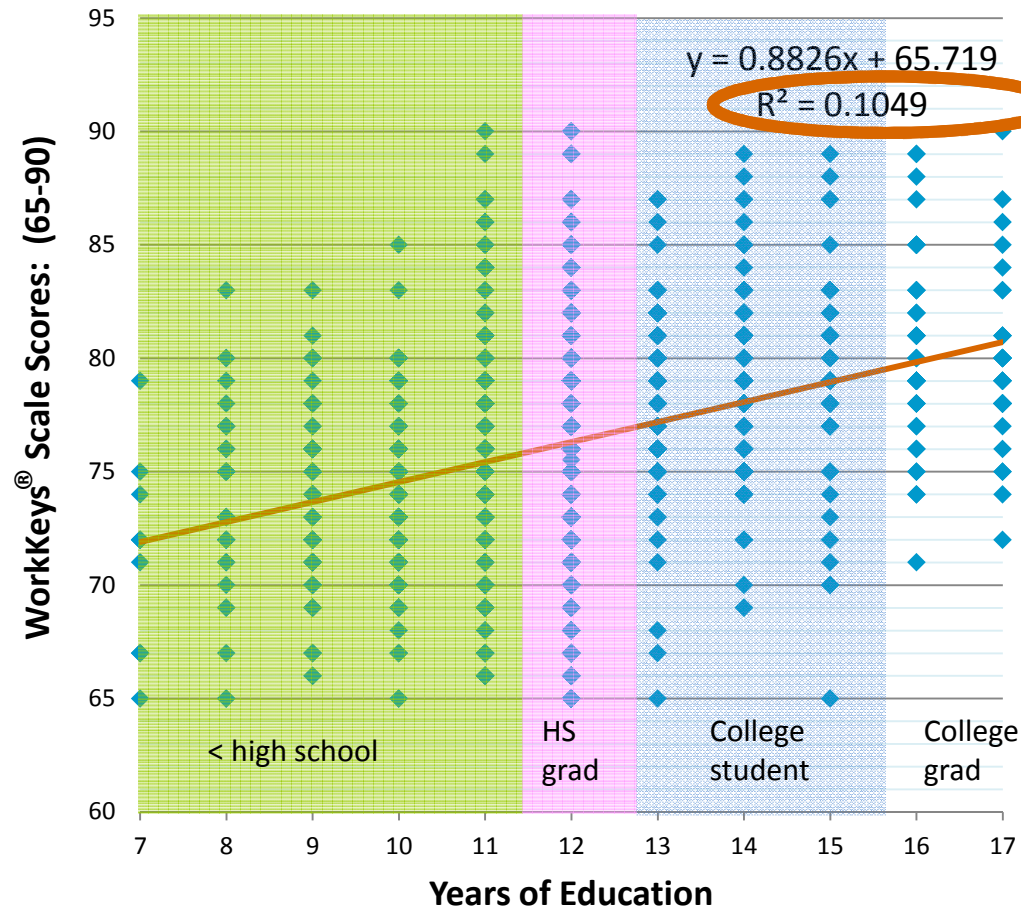
| O*Net Code | Title  | Clusters  |
|------------|--|---|
| 17-2011.00 | Aerospace Engineers                          | Science, Technology, Engineering & Mathematics                          |
| 17-2021.00 | Agricultural Engineers                       | Science, Technology, Engineering & Mathematics                          |
| 17-1011.00 | Architects, Except Landscape and Naval       | Architecture & Construction   |
| 17-2031.00 | Biomedical Engineers                         | Science, Technology, Engineering & Mathematics                          |
| 17-2041.00 | Chemical Engineers                           | Science, Technology, Engineering & Mathematics                          |
| 17-2051.00 | Civil Engineers                              | Science, Technology, Engineering & Mathematics                          |
| 15-1011.00 | Computer and Information Scientists, Rese... | Health Science; Info Tech   |
| 17-2061.00 | Computer Hardware Engineers                  | Info Tech; Sci / Tech / Eng / Math                                      |
| 15-1031.00 | Computer Software Engineers, Applications    | Health Science; Info Tech; Manufacturing; Sci / Tech / Eng / Math       |
| 11-9041.00 | Engineering Managers                         | Arch / Construction; Gov / Public Admin; Info Tech; Sci / Tech / Eng... |
| 11-1021.00 | General and Operations Managers              | Bus / Mgmt / Admin; Gov / Public Admin                                  |
| 17-2111.00 | Health and Safety Engineers, Except Minin... | Science, Technology, Engineering & Mathematics                          |
| 17-2121.02 | Marine Architects                            | Science, Technology, Engineering & Mathematics                          |
| 17-2121.01 | Marine Engineers                             | Science, Technology, Engineering & Mathematics                          |
| 17-2121.00 | Marine Engineers and Naval Architects        | Science, Technology, Engineering & Mathematics                          |
| 17-2131.00 | Materials Engineers                          | Science, Technology, Engineering & Mathematics                          |
| 19-2032.00 | Materials Scientists                         | Science, Technology, Engineering & Mathematics                          |
| 17-2151.00 | Mining and Geological Engineers, Includin... | Science, Technology, Engineering & Mathematics                          |
| 17-2161.00 | Nuclear Engineers                            | Science, Technology, Engineering & Mathematics                          |
| 17-2171.00 | Petroleum Engineers                          | Science, Technology, Engineering & Mathematics                          |
| 19-2012.00 | Physicists                                   | Health Science; Sci / Tech / Eng / Math                                 |
| 17-2111.03 | Product Safety Engineers                     | Science, Technology, Engineering & Mathematics                          |

From the ACT, Inc occupational database at [http://profiles.keytrain.com/profile\\_search/](http://profiles.keytrain.com/profile_search/)

But why can only 6% of the U.S. population score a level 7 in 6<sup>th</sup> grade math?

The ability to code a “real situation” into math, i.e., to **apply** math, is almost never taught and completely missing, not only in K-12 but also the graduate level. This may also explain the U.S.’ poor PISA results.

Only 10% of an individual's ability to apply math, can be explained by years in school



**Correlation= .32**  
**N=1809**

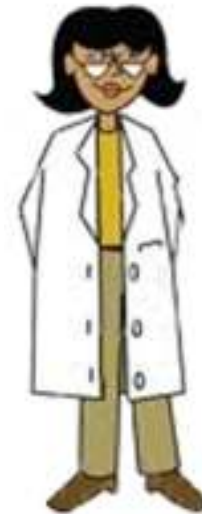
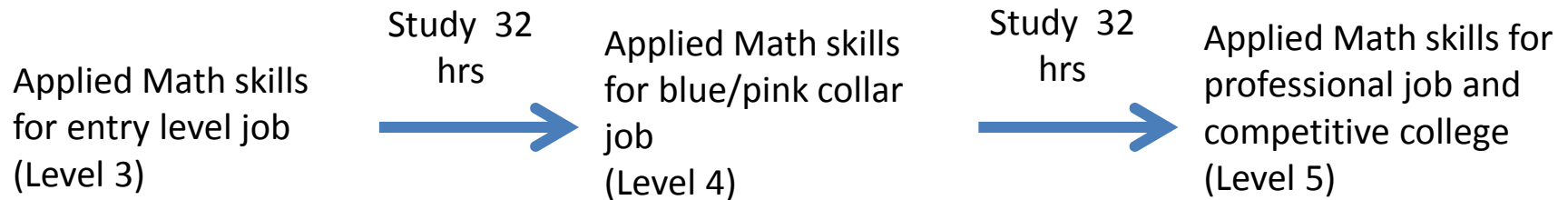
Targeted curricula can do in one year what it takes school 6 years to accomplish

|  | Applied Math Gain          |
|--|----------------------------|
| Keytrain<br>(California data,<br>Kilijanek analysis) | 5.8/yr<br>(N=132; p<0.001) |
| School (N $\approx$ 1800,<br>New Mexico)             | 0.88/yr                    |



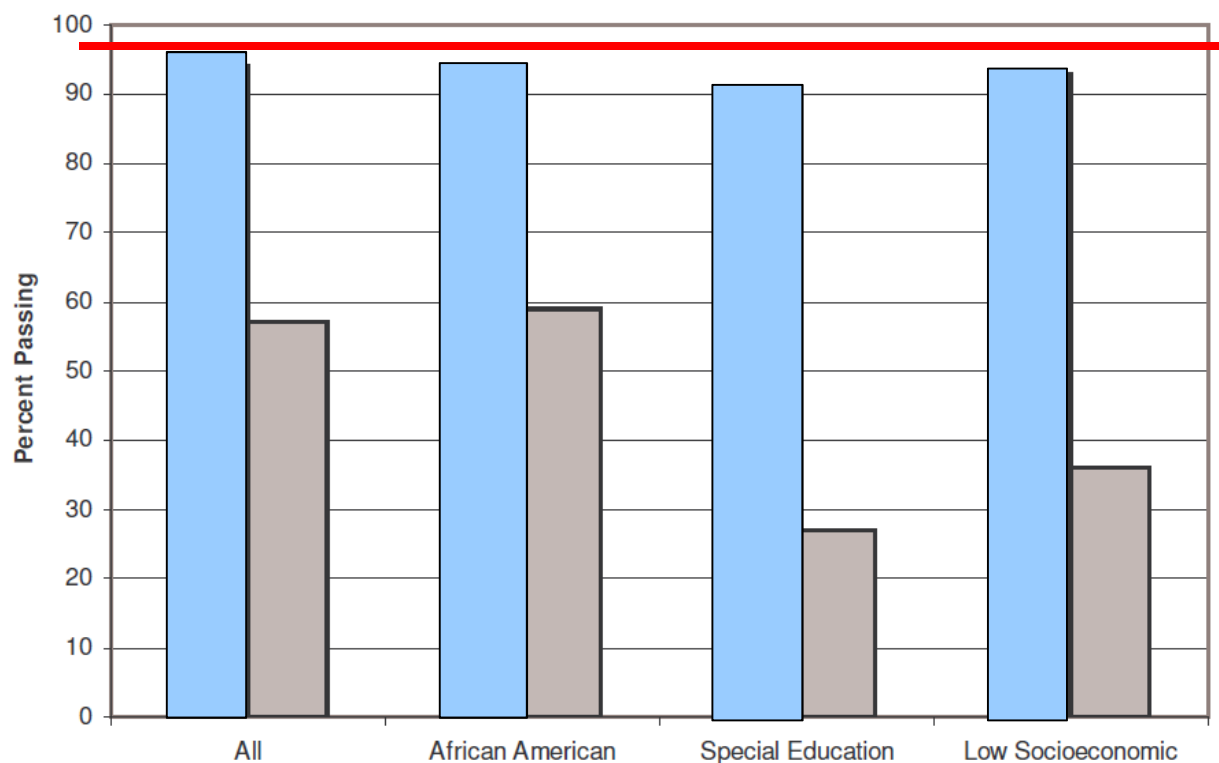
# What California data really means

(data from Nevada and New Mexico are consistent with this)



# Georgia High School Graduation Test, Math

GHSGT Mathematics Results (Experimental Vs. Control)



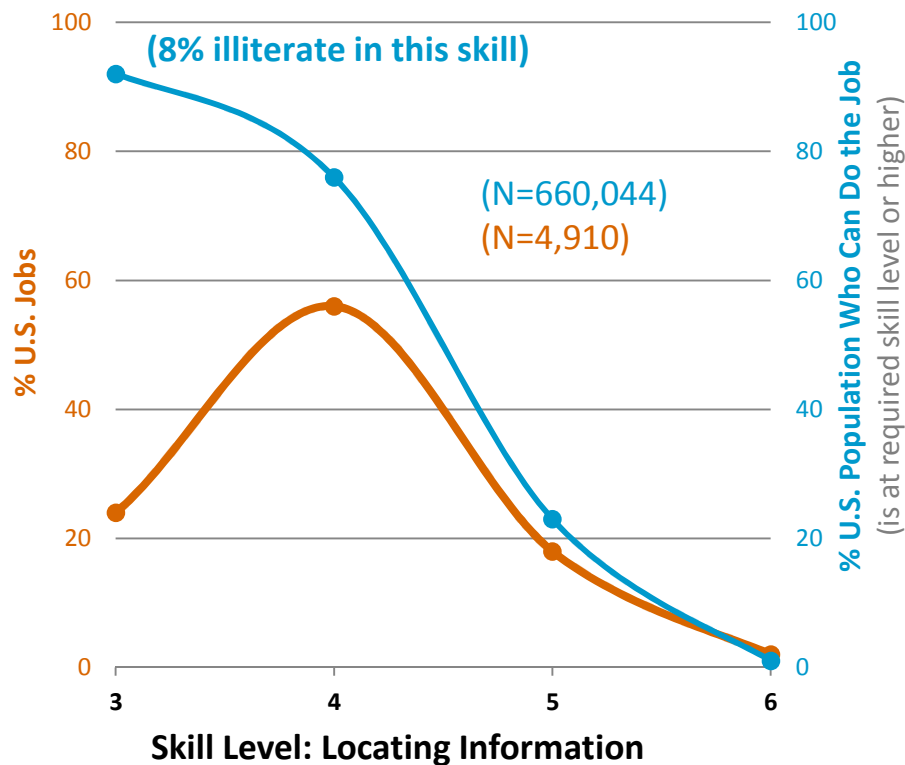
White, Statewide

Used Keytrain®

Did Not Use Keytrain®



# Understanding charts & diagrams ("Locating Information") is actually a bigger problem than Applied Math



There is not enough “excess” high skill population for employers to demand this skill at high levels PLUS any other criterion (e.g., individual lives in their state, has a particular degree, is a U.S. citizen, has prior experience).

## National deficiency in Locating Information is a major contributor to the “STEM crisis”

| O*Net Code | Title   | Clusters   |
|------------|---|--|
| 17-2011.00 | Aerospace Engineers                           | Science, Technology, Engineering & Mathematics                   |
| 17-1011.00 | Architects, Except Landscape and Naval        | Architecture & Construction                                      |
| 13-1051.00 | Cost Estimators                               | Arch / Construction; Bus / Mgmt / Admin; Sci / Tech / Eng / Math |
| 51-4032.00 | Drilling and Boring Machine Tool Setters, ... | Manufacturing  |
| 17-2199.00 | Engineers, All Other                          |  |
| 11-9061.00 | Funeral Directors                             | Human Services   |
| 11-1021.00 | General and Operations Managers               | Bus / Mgmt / Admin; Gov / Public Admin                           |
| 17-1012.00 | Landscape Architects                          | Architecture & Construction                                      |
| 19-2032.00 | Materials Scientists                          | Science, Technology, Engineering & Mathematics                   |
| 19-2012.00 | Physicists                                    | Health Science; Sci / Tech / Eng / Math                          |
| 13-1021.00 | Purchasing Agents and Buyers, Farm Pro...     | Agriculture, Food & Natural Resources                            |
| 27-3042.00 | Technical Writers                             | Arts / AV Tech / Comm; Bus / Mgmt / Admin                        |

# The “Workplace Math” View of the World is So Different

## CONVENTIONAL WISDOM

- You need a lot of math content/courses if you want a good job.
- Taking math courses gives you the ability to apply math.
- School degrees are a good first cut to predict who will perform on the job.

## WORKPLACE SKILLS VIEW

- You need to be able to **apply** math if you want a good job, but only at the 6<sup>th</sup> grade level.\*Some exceptions apply
- Pre- and post-testing of even college algebra class show zero gains in applied math skill, because content was taught but critical thinking was not (NONM data).
- School degrees predict 1-10% of work performance variation. Cognitive skills tests are 5-25 times more effective as a first screen.

The Inability to Code Real-World Situations into Math (to “Apply” Math) Occurs Even in Graduates of College Programs DESIGNED to Teach Applied Math – (e.g., Financial Engineering/Computational Finance)



# Proof: Employers are desperate to hire in this field

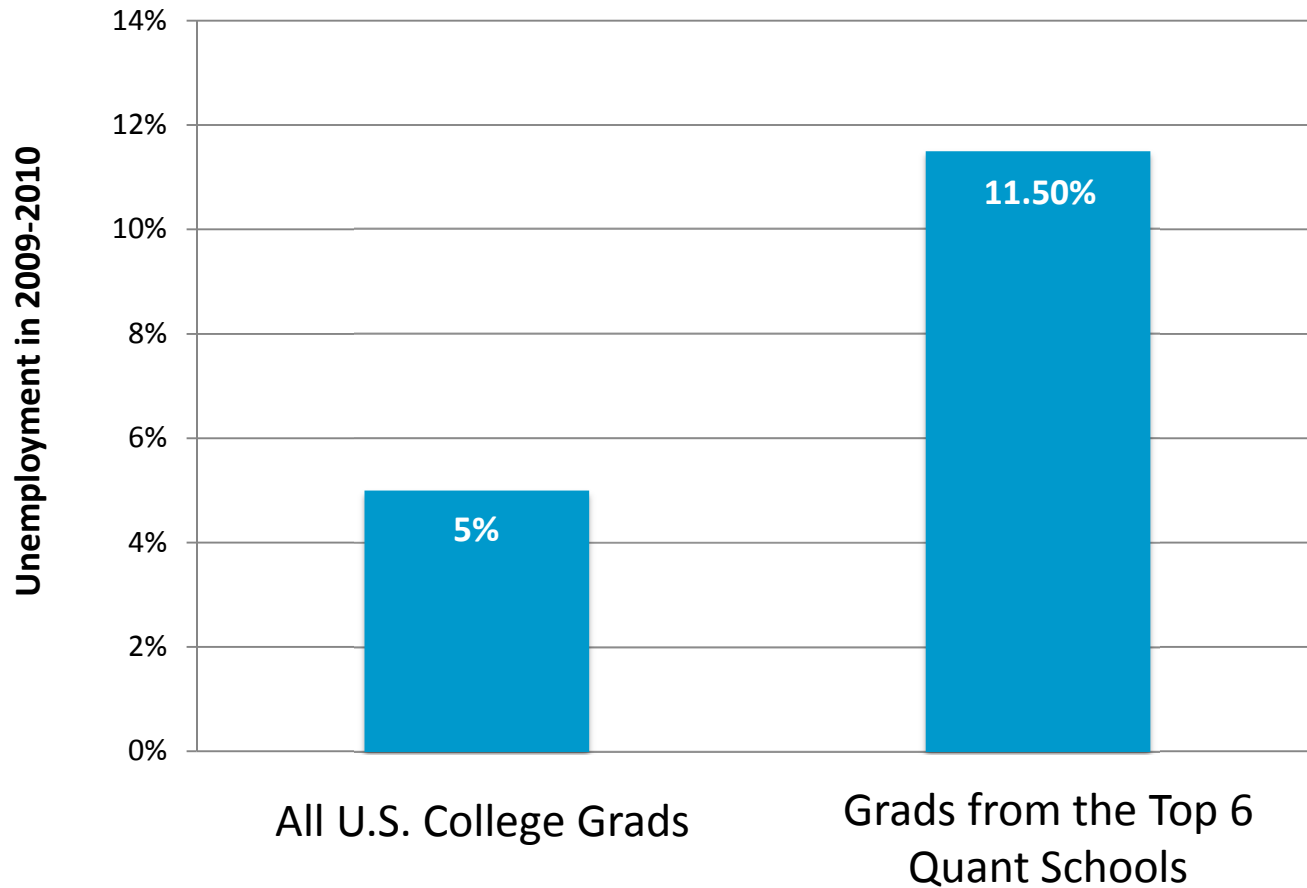
**Junior Quantitative Analyst, PhD Machine Learning or Signal Processing – Investment Bank – NYC, \$250k**  
PhD from a well-regarded university, in Physics, Computer Science, Machine Learning, Signal Processing, Computer Vision, Statistics, Econometrics, Operations Research

**PhD Quant Analyst (High-Performance Computing) – Fixed Income Research – NYC, \$250k**  
PhD in a Quantitative/Scientific subject. PhD from a top-tier university.

**Quant Developer/ Algo Developer – Algorithmic Trading Firm – Chicago, \$175-250k**  
To qualify for this position, you will have a Bachelors, Masters or PhD in Computer Science etc. from a red brick university with a high GPA.

**From one week's job postings in Quantjobs.com**

But they consider college graduates  
in this field unemployable



(Berkeley, CMU, Columbia, Cornell, NYU, Stanford)

# How Can This Be?

“All over the world, it has become fashionable for Universities and Colleges to offer Masters degree programs in quantitative finance or financial engineering (FE), a code word meaning the solution of the Black-Scholes option pricing differential equation in as many ways as possible.

“Unless the [academic] field re-invents itself pronto and starts becoming relevant to what people actually do out there, graduates with newly minted financial engineering degrees hoping to see a decent return on their own or their parents’ sizable investment will continue to be sorely disappointed by their actual career prospects, and will keep wondering where in God’s name they went wrong.”

**-Sylvain Raynes**

Founding Principal of R&R Consulting, a structured credit metrics consultancy

Better to teach students to see the world in terms of math, so they can solve 6<sup>th</sup> grade math problems and hold a job, than to never teach them this skill, and be unemployable all the way through a graduate degree.



**In New Mexico, We Are Moving Employers  
Away From “Degree-Based Hiring” Towards  
“Skill-Based Hiring.”**

New Mexico Job Order Print Document

**Job Information:**

Job Order: 260354

Print Date: 4/22/2013 3:03:38 PM

Job Title: **Teacher Assistant/Artesia**

Occupational Code: **25904100 Teacher Assistants**

Industry Code: Confidential Information

Type of Job: **Regular**

Job Time Type: **Full Time (30 Hours or More)**

Duration: **Over 150 Days**

Special Job Category:

Green Job: **Not Specified**

Job Created from ARRA (Stimulus): **No**

Employer Name: **Not Available**

**Job Duties and Skills:**

Description:

**Veterans Preference: To ensure compliance with the Jobs for Veterans Act, this job posting will be available only to veterans for the first 24 hours from 4/15/13 until 4/16/13. After this period, the job will be released to all job seekers.**

**Perform duties that are instructional in nature or deliver direct services to students or parents. Serve in a position for which a teacher or another professional has ultimate responsibility for the design and implementation of educational programs and services. Must have 6 months early childhood related work experience. Must obtain Child Development Associate credential/or State Certificate within three and a half years from date of hire. possess excellent oral and written English communication skills. Must have a high school diploma or GED. APPLY AT CARLSBAD WORKFORCE CONNECTION-VJFSC/NM/LV9182**

WorkKeys Preferred:

RI- 4

AM- 4

LI- 3

Teacher Assistant in Artesia = Workkeys® Reading Level 4, Applied Math 4, Locating Info Level 3

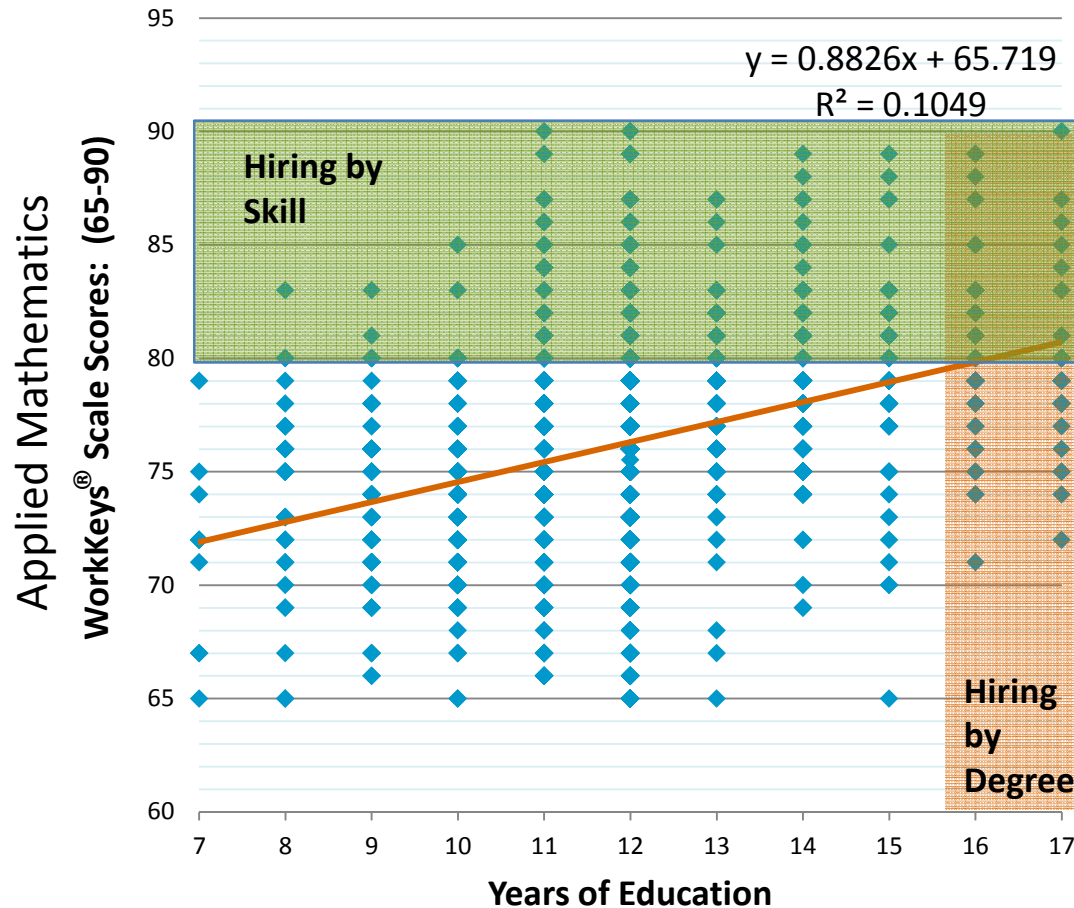


I need someone who is a  
Level 5 in Listening, a Level  
4 in Applied Math.

That's me!!! I have those  
scores!



Only 10% of an individual's ability to apply math, can be explained by years in school



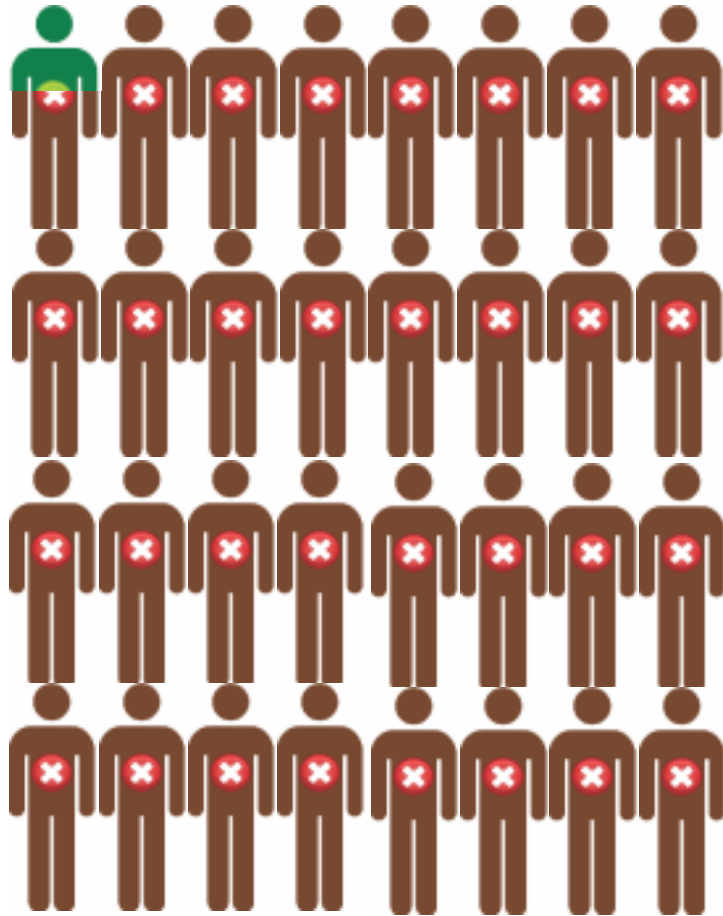
Correlation= .32  
N=1809

Data from NMDWS; analysis by Tom Kilijanek

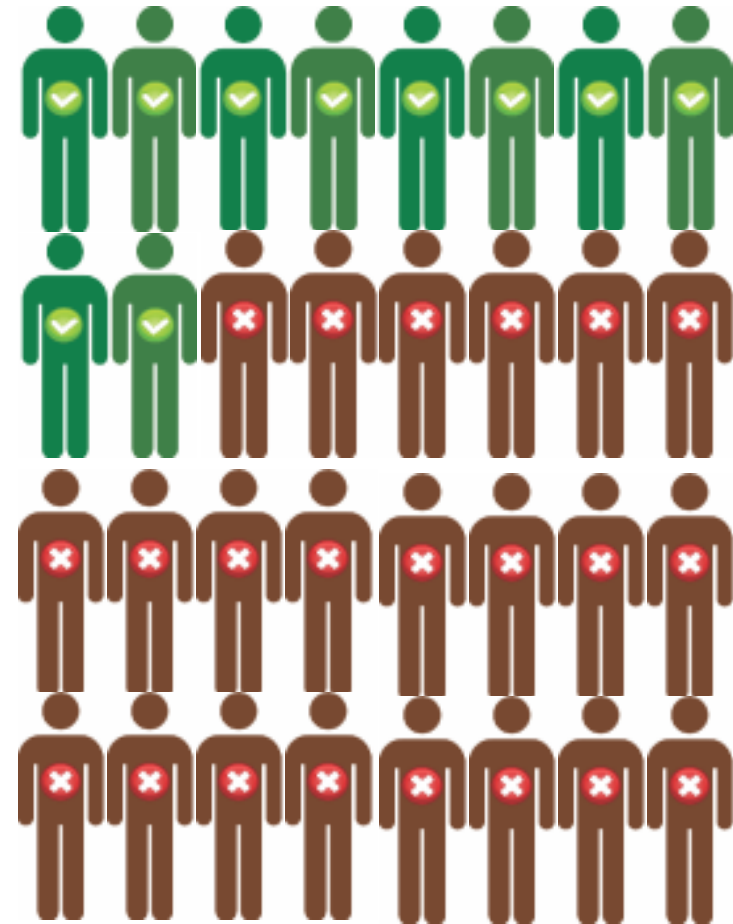
WorkKeys is a registered trademark of ACT, Inc. For more information please visit <http://www.act.org/products/workforce-act-workkeys/>

# *Impact* on Job Placement

For jobs requiring a college degree:



1% of unemployed New Mexican youth eligible if by Degree



33% of unemployed New Mexican youth eligible if by Skill