NΣΣDΣD MΛTH

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The Needed Math Project – *Promoting Student Success in Manufacturing Workplaces*

Introductions

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Overview of This Talk

- Part I: Introduction to *Needed Math* project
- Part II: Provide results from project’s national survey of educators and technicians
- Part III: Scenarios

Part I: Intro

We Think There is a Problem Relating to Math

-Hence our grant project

Two quotes that nicely summarize the problem(s) with math

Quote from Educator Who Completed Survey

“K-12 (and college) math is taught as a purely theoretical construct, to prepare students for more advanced math classes, as if everyone is going to be a math major in college. This is completely wrong-headed and results in people fearing and hating math. Historically, most mathematics was developed to do things in the real world such as … calculating the area of a house, …or calculating energy needed to heat a house. Math should be taught that way up until college… we need to stop avoiding teaching math as a practical tool for the vast majority of people, just so that we can prepare a small minority of people to love the beauty of theoretical math so that they can be good math majors in college. And then go on to be math teachers, thereby propagating the cycle.”

Quote from a Completed Survey

"I am very passionate about this topic because although my students have all had 12+ years of math classes, most do not feel they are good at it, do not like it, and *do not know how to use math as a tool*. Their math classes were not application-based but instead were all theory. The few applications they were taught, such as the famous "A train leave Chicago at 2PM travelling east at 45 miles per hour…" are so contrived that they give students no idea what math is useful for in their real lives."

The *Needed Math Project*

NEEDED MATH is a three-year Targeted Research Project in Technician Education to improve alignment of the mathematics taught in two-year technical college programs with the math manufacturing technicians use in the workplace.

Part II: The Survey

Survey Development

- Research project, and first part of project was a survey
- Survey development was complex and difficult
- Occurred over 2.5 years

Survey Development

- **Initial research included:**
  - industry site visits
  - reviewing manufacturing skill sets, competency models, etc.
  - reviewing various common core math standards
  - reviewing certification exams relating to manufacturing
  - interviews/meetings with various math education groups
  - reviewing technical mathematics textbooks

Team Created Survey: Based on Initial Research Findings

- 40 items identified and compiled into survey format

Survey sections

Section 1: Measurement

Section 2: Statistics

Section 3: Algebra

Section 4: Geometry, Trig

Section 5: Arithmetic

Section 6: Using Technological Tools

Section 7: Modelling

For Example

MEASUREMENT

1. Make conversions between units of measurement (for example, inches to centimeters)
2. Work with ratios or rates (for example, percentages, concentrations, speed)
3. Take measurements using physical tools (for example, calipers, micrometers, scales) or instruments (for example, voltmeters, oscilloscopes, pressure gauges).
4. Make estimates (for example, of measurements, quantities, production runs)
5. Do work that requires accuracy to a specified tolerance (for example, +/- 5%, +/- 0.003 inches)

Survey

- Used the survey to determine where there is consensus and where significant differences between math educators, technical educators, and technicians in:
  - Frequency of use of specific math tools
  - Preparation of technicians to use those math tools

Three Groups Surveyed

- Math educators in two-year college settings
- Technical educators in two-year college settings
- Technicians in manufacturing workplaces

Survey

- Draft survey was tested with small group
- Final survey was sent to more than 10,000 people and to colleagues
- ≈ 560 people completed entire survey

For Each Math Tool on the Survey, Two Ratings

1. On scale of 1-5, how often do you, as part of your job in manufacturing, need to…

2. On scale of 1-5 how well do you believe courses required in school prepare manufacturing technicians to do this task on the job?

Results: Frequency

Item #	Item Wording	Math Educators MEd)		Tech Educators (TEd)		Technicians		Whole Group (WG) Ranking		
		MEd Rank	MEd Mean	TE Rank	TEd Mean	Tech Rank	Mean	By Rank	WG Mean	By Item
Q3	Take measurements using physical tools or instruments (Freq)	1	4.80	1	4.80	1	4.71	1	4.77	Q3
Q26	Use blueprints, diagrams, drawings, flow charts, or schematics (Freq)	7	4.56	2	4.61	5	4.36	2	4.51	Q26
Q28	Use metric (or SI) prefixes (Freq)	3	4.68	7	4.35	2	4.56	3	4.48	Q28
Q4	Make estimates (Freq)	2	4.72	4	4.48	6	4.35	4	4.48	Q4
Q2	Work with ratios or rates (Freq)	6	4.60	6	4.36	3	4.42	5	4.42	Q2
Q6	Read, document, and/or interpret sensor data (Freq)	5	4.65	5	4.43	10	4.12	6	4.36	Q6
Q5	Do work that requires accuracy to a specified tolerance (Freq)	4	4.68	3	4.50	11	3.98	7	4.35	Q5
Q39	Use data to troubleshoot problems (Freq)	10	4.19	8	4.25	4	4.38	8	4.28	Q39
Q1	Make conversions (Freq)	12.5	4.08	9	4.16	7	4.24	9	4.18	Q1
Q31	Make conversions between different ways of expressing numbers (Freq)	8	4.37	10	4.04	8	4.21	10	4.15	Q31
Q8	Read and interpret tables, graphs, or plots of data (Freq)	15	4.06	11	4.00	9	4.18	11	4.07	Q8
Q32	Work with prepared spreadsheets (Freq)	14	4.07	12	3.79	12	3.83	12	3.85	Q32
Q21	Use spatial reasoning (Freq)	9	4.30	13	3.78	19	3.35	13	3.72	Q21
Q7	Use sampling to collect data (Freq)	21	3.73	14	3.66	17	3.39	14	3.58	Q7
Q22	Use angle measurements (Freq)	11	4.09	15	3.62	23	3.23	15	3.57	Q22
Q34	Use a scientific or graphing calculator (Freq)	19	3.85	18	3.57	20	3.34	16	3.54	Q34
Q11	Read and analyze control charts (Freq)	12.5	4.08	17	3.58	27	3.17	17	3.53	Q11
Q37	Use math to prepare reports (Freq)	24	3.66	20	3.49	21	3.32	18	3.46	Q37
Q13	Substitute numbers into formulas and evaluate (Freq)	16	3.92	25	3.25	14	3.48	19	3.44	Q13
Q20	Use geometric topics (Freq)	25	3.65	19	3.54	26	3.20	20	3.44	Q20
Q36	Collect, analyze, and use information from a system (Freq)	18	3.87	16	3.60	31.5	2.93	21	3.42	Q36
Q18	Find perimeters, areas, or volumes (Freq)	17	3.92	22	3.38	25	3.21	22	3.41	Q18
Q10	Use, interpret, or calculate statistical measures (Freq)	27	3.45	24	3.28	13	3.53	23	3.40	Q10
Q27	Use scientific or engineering notations (Freq)	20	3.82	28	3.12	15	3.45	24	3.35	Q27
Q16	Use direct or inverse variation (Freq)	22	3.72	23	3.36	29	3.11	25	3.33	Q16
Q12	Use data to optimize a production process (Freq)	30	3.39	21	3.40	28	3.12	26	3.30	Q12
Q25	Work with amplitude, frequency, or period (Freq)	31	3.31	27	3.17	16	3.44	27	3.29	Q25
Q30	Use inequalities (Freq)	26	3.65	29	3.09	22	3.30	28	3.25	Q30
Q9	Make tables, graphs, or plots of data (Freq)	34	3.19	30	3.08	18	3.38	29	3.15	Q9
Q33	Use spreadsheets for tasks beyond working with prepared spreadsheets (Freq)	32	3.27	32	2.95	24	3.21	30	3.10	Q33
Q24	Use right triangle trigonometry (Freq)	29	3.39	33	2.94	34	2.81	31	2.98	Q24
Q23	Use Geometric Dimensioning and Tolerance (Freq)	23	3.69	31	3.08	36	2.46	32	2.96	Q23
Q38	Use graphs, tables, data, formulas or simulations (Freq)	33	3.23	34	2.75	31.5	2.93	33	2.90	Q38
Q17	Work with exponential functions (Freq)	37	2.72	35	2.71	30	3.06	34	2.83	Q17
Q35	Use math when using a CNC system (Freq)	28	3.41	26	3.19	40	1.94	35	2.79	Q35
Q15	Fit a curve to data (Freq)	36	2.78	37	2.49	35	2.76	36	2.63	Q15
Q19	Work with logarithms (Freq)	38	2.68	39	2.47	33	2.83	37	2.63	Q19
Q40	Use math to forecast performance measures or future outcomes (Freq)	35	2.95	38	2.47	37	2.31	38	2.50	Q40
Q14	Manipulate a formula to get a new formula (Freq)	39	2.57	36	2.55	39	1.98	39	2.47	Q14
Q29	Use complex numbers (Freq)	40	1.87	40	1.83	38	2.17	40	1.95	Q29
			149.59		139.17		135.73			

items highlighted in yellow indicate a significant ANOVA result with a p-value less than 0.05.

Results: Preparation

Item #	Item Wording	Math Educators MEd)		Tech Educators (TEd)		Technicians		Whole Group (WG) Ranking		
		MEd Rank	MEd Mean	TE Rank	TEd Mean	Tech Rank	Mean	By Rank	WG Mean	By Item
Q31A	Make conversions between different ways of expressing numbers (Prep)	2	3.48	4.5	3.26	2	3.03	1	3.22	Q31A
Q28A	Use metric (or SI) prefixes (Prep)	7	3.16	1	3.32	3	3.02	2	3.19	Q28A
Q2A	Work with ratios or rates (Prep)	5	3.26	4.5	3.26	7.5	2.90	3	3.13	Q2A
Q18A	Find perimeters, areas, or volumes (Prep)	3	3.40	9	3.13	6	2.94	4	3.11	Q18A
Q13A	Substitute numbers into formulas and evaluate (Prep)	1	3.63	13	3.08	9	2.88	5	3.11	Q13A
Q1A	Make conversions (Prep)	8	3.16	6	3.19	7.5	2.90	6	3.08	Q1A
Q34A	Use a scientific or graphing calculator (Prep)	4	3.33	8	3.14	15	2.71	7	3.03	Q34A
Q8A	Read and interpret tables, graphs, or plots of data (Prep)	9	3.13	10	3.11	11	2.83	8	3.02	Q8A
Q22A	Use angle measurements (Prep)	6	3.22	11	3.11	14	2.74	9	3.00	Q22A
Q3A	Take measurements using physical tools or instruments (Prep)	20	2.66	2	3.32	18.5	2.64	10	2.97	Q3A
Q30A	Use inequalities (Prep)	10	3.12	18	2.93	5	2.94	11	2.97	Q30A
Q20A	Use geometric topics (Prep)	13	2.98	14	3.06	13	2.77	12	2.95	Q20A
Q27A	Use scientific or engineering notations (Prep)	12	3.02	17	2.95	10	2.85	13	2.93	Q27A
Q9A	Make tables, graphs, or plots of data (Prep)	15	2.86	20	2.88	1	3.27	14	2.93	Q9A
Q5A	Do work that requires accuracy to a specified tolerance (Prep)	21	2.63	7	3.16	17	2.65	15	2.89	Q5A
Q4A	Make estimates (Prep)	16	2.84	15	3.06	18.5	2.64	16	2.88	Q4A
Q24A	Use right triangle trigonometry (Prep)	11	3.03	21	2.86	12	2.79	17.5	2.87	Q24A
Q6A	Read, document, and/or interpret sensor data (Prep)	22	2.59	12	3.09	16	2.69	17.5	2.87	Q6A
Q14A	Manipulate a formula to get a new formula (Prep)	14	2.88	23	2.81	4	3.02	19	2.86	Q14A
Q26A	Use blueprints, diagrams, drawings, flow charts, or schematics (Prep)	27	2.34	3	3.27	26	2.50	20	2.85	Q26A
Q39A	Use data to troubleshoot problems (Prep)	30.5	2.31	16	2.95	25	2.55	21	2.71	Q39A
Q32A	Work with prepared spreadsheets (Prep)	32	2.27	19	2.90	20	2.64	22	2.70	Q32A
Q17A	Work with exponential functions (Prep)	17	2.82	28	2.61	23	2.59	23	2.64	Q17A
Q10A	Use, interpret, or calculate statistical measures (Prep)	19	2.74	29	2.60	21	2.63	24.5	2.64	Q10A
Q7A	Use sampling to collect data (Prep)	23	2.43	22	2.85	29	2.43	24.5	2.64	Q7A
Q16A	Use direct or inverse variation (Prep)	18	2.76	25	2.67	28	2.44	26	2.61	Q16A
Q37A	Use math to prepare reports (Prep)	29	2.32	27	2.64	22	2.60	27	2.57	Q37A
Q25A	Work with amplitude, frequency, or period (Prep)	24	2.41	26	2.67	30	2.42	28	2.54	Q25A
Q21A	Use spatial reasoning (Prep)	30.5	2.31	24	2.73	36	2.16	29	2.46	Q21A
Q15A	Fit a curve to data (Prep)	26	2.37	35	2.39	24	2.59	30	2.46	Q15A
Q19A	Work with logarithms (Prep)	25	2.38	36	2.38	27	2.47	31	2.41	Q19A
Q11A	Read and analyze control charts (Prep)	34	2.19	31	2.57	33	2.18	32	2.37	Q11A
Q12A	Use data to optimize a production process (Prep)	28	2.33	33	2.50	35	2.17	33	2.36	Q12A
Q36A	Collect, analyze, and use information from a system (Prep)	35	2.18	30	2.57	37	2.10	34	2.35	Q36A
Q38A	Use graphs, tables, data, formulas or simulations (Prep)	36	2.17	37	2.32	31	2.34	35	2.30	Q38A
Q33A	Use spreadsheets for tasks beyond working with prepared spreadsheets (Prep)	38	1.96	34	2.44	32	2.28	36	2.30	Q33A
Q35A	Use math when using a CNC system (Prep)	37	2.13	32	2.53	39	1.97	37	2.27	Q35A
Q29A	Use complex numbers (Prep)	33	2.20	39	2.12	34	2.17	38	2.15	Q29A
Q23A	Use Geometric Dimensioning and Tolerance (Prep)	39	1.96	38	2.31	40	1.93	39	2.12	Q23A
Q40A	Use math to forecast performance measures or future outcomes (Prep)	40	1.91	40	2.07	38	2.03	40	2.03	Q40A
			106.85		112.78		103.41			
	items highlighted in yellow indicate a significant ANOVA result with a p-value less than 0.05.									

This is a spreadsheet showing the ratings by subgroup of the survey

Interpretation

- There are statistically significant differences between groups in items highlighted in yellow
- Project statisticians are still working on interpreting all these results
- So, today, will provide only our own broad takeaways from the results

Takeaway 1

- Survey successfully identified almost 40 items that all three surveyed groups agree are frequently used in the workplace, and, we would therefore say are of high importance
- A few items are specific to particular workplaces (e.g., CNC) and therefore scored lower in frequency of use

Takeaway 2

- *Items relating to **measurements** ranked most highly.* This includes:
  - Q3. Take measurements using physical tools (for example, calipers, micrometers, scales) or instruments (for example, voltmeters, oscilloscopes, pressure gauges).
  - Q2 Work with ratios or rates (for example, percentages, concentrations, speed)
  - Q4. Make estimates (for example, of measurements, quantities, production runs)
  - Q5. Do work that requires accuracy to a specified tolerance (for example, +/- 5%, +/- 0.003 inches)
  - Q28. Use metric (or SI) prefixes (for example, micro, kilo)
  - Q6. Read, document, and/or interpret sensor data (for example from temperature, pressure, or flow sensors)

- The only task in the top 7 (for frequency) that is perhaps less related to measurement topics is Q26. "Use blueprints, diagrams, drawings, flow charts, or schematics." However, measurements might still be important in interpreting such things as blueprints.

Takeaway 3

- *Scores for preparation across the board are lower than for frequency of use*. Overall, averaging the results of all 40 survey items:
  - Technicians’ average was **2.58** for preparation and **3.48** for frequency.
  - Tech educators’ average was **2.80** for preparation and **3.54** for frequency.
  - Math educators’ average was **2.67** for preparation and **3.83** for frequency.

Takeaway 4

- *An essential question asked in the grant proposal is whether there are differences in perception among the three groups in the importance of various math skills and the preparation of technicians entering their jobs*.
- We think that overall, the three groups agree – even though there are some statistically significant differences in certain items
- Overall, math educators think items are used somewhat more frequently than the other two groups and technicians had overall lowest scores for frequency – but this is not surprising
    - Educators prepare students for an array of jobs and know that individuals will use a subset of what is taught

A Comment about Measurements

We think measurements are vital, but that is not necessarily reflected in math education. Has a fifth grader really mastered measurements?

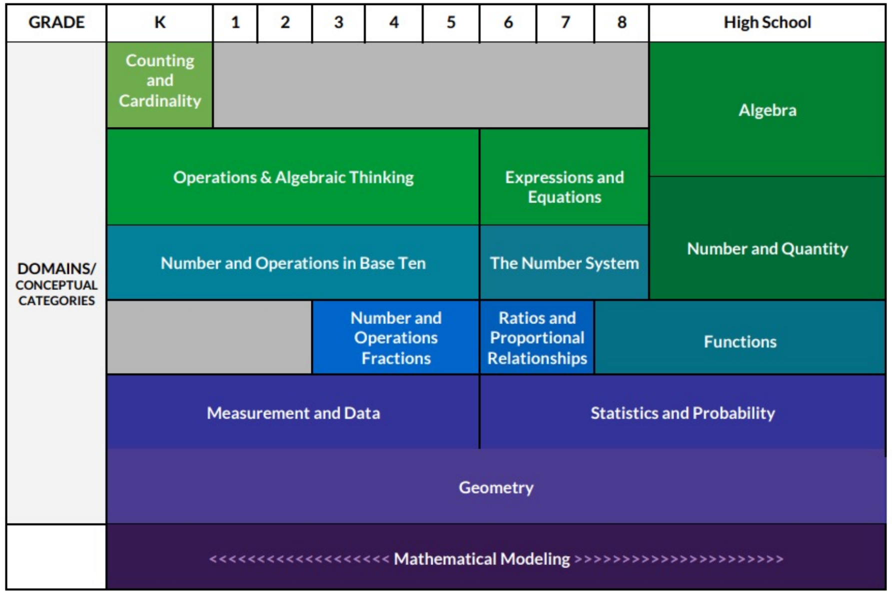

Figure from Wisconsin State Math Common Core Skill Standards

Part III: Scenarios

Scenarios

- Next stage of project is to provide “scenarios”
- Based on ideas supplied by industry colleagues
- Supposed to show how math arises in the “real-world” workplaces
- Scenarios not supposed to be like math textbook problems

Scenarios

- Can be used:
  - Make more concrete what is meant by survey items
  - To communicate how math is used in the workplace
  - For education
  - To show how the same math tools are applied in a variety of settings

Writing Scenarios

- Scenarios proved to be difficult to write
- Major reason they are difficult to write is the same as the reason people have difficulty with workplace math:
  - Math arises surrounded by context
  - Require specialized knowledge to “find” the math
  - Scenario writers need to show that context to readers who may not have specialized knowledge
- We have found scenarios powerfully illustrate why people have difficulty with required math – team members often find it very difficult to interpret other team member’s scenarios

Example Provided by Beer Brewer QC Analyst

Tyler says: “[This calculation is] often used to predict when a tank of beer can be either bunged or cooled. [This is a] pretty straight forward calculation but is very useful for us. [It is a] basic rate calculation but it is then also turned back around and used with our known information to predict when actions can be taken on a fermentation. For example: A fermentation has a measured gravity of 5.00 °Plato at 4 PM, at 8 AM it had been at 6.5 °Plato. If we want to bung this fermentation at 4.00 °Plato, we need to first calculate our rate of fermentation and then … use that rate to determine when we should achieve our target gravity.”

Leads to Questions We Want to Ask

- What are the barriers to using math in the workplace?
- How can we supply rich, workplace contextualization?
- Who should /could use scenarios like the *Needed Math* scenarios?
- How could they be made better? (is anything missing?)

Needed Math Project Final Year

- Complete and disseminate analysis of results
- Create and disseminate Scenarios
- Establish collaborative working groups for project sustainability
- Finalize data analysis, report outcomes

Thank you all!

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FOR FURTHER INFORMATION

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