

The logo for the Southwest Center for Microsystems Education (SCME), consisting of a glowing orange gear-like shape with the letters 'SCME' in white.

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Knowledge and Skills Needed by MEMS Technologists as Ascertained by Industry Survey and Job Profiling

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Southwest Center for Microsystems Education

Central New Mexico Community College

School of Applied Technologies

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Central Question:

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How do we determine what knowledge and skills a successful technologist should have?

This information is required in order to create the best set of educational and professional development materials.

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Multidisciplinary Approach



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• **Industry Survey Was Done Online www.scme-nm.org link to Zoomerang**

– **Could also download a paper version and mail/fax to us!**

****** No One used Paper Version! Lesson Learned***

- **Job Profiling and Shadowing by David Licht – CNM WorkKeys Certified Job Profiler**

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Creating The Survey

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- Advisory Panel Input
 - Revision 1:
 - “Looks like an Engineer Wrote it” – David Williams, Sandia
 - “I wouldn’t take the survey, its too long and I don’t have time” – Doug Elerath – HT Micro
 - Several interactions with input from the Advisory Panel.

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Survey Contributors

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HT Micro

XCOM

Intel

JPL

Texas Instruments

Sandia National
Laboratories

BioLink

MATEC

NCME

MANCEF

NACFAM

Ohio MEMS

MSU

NMSU

UNM

NNMCC

SIPI

NMT

UC Davis

CCSF

TVI

TVC

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Final Revision

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- **Final Revision – Easy to use – about 20-30 minutes to fill out!**

“I can see that you heard your advisory group's comments and have worked hard and well toward an improved product. That means a lot to this member -- we have each made time in our schedules and given SCME priority in our thinking. We do this because we believe in you and the SCME vision. Your response to our inquiry and feedback helps us justify the "Saturday Time" it takes to meet with you and respond to your needs. Thank you for honoring us with your listening and your doing. “ – David Williams

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Industry Survey Update

(from Survey Preface)

The goal of this survey is to assess the needs of the Microsystems industrial needs with regard to Technologist Education. This will assist the Southwest Center for Microsystems Education (a National Science Foundation funded Advanced Technological Education Center), in establishing a basis to produce a set of Skill Standards and Competencies required for a Microsystems Technologist. These competencies and skill standards will guide us in the development of educational materials.

Technician:

A person who is an expert in a specific technique or process, follows established methods and procedures, and typically carries out work under the direct supervision of another. Examples include: an electronics technician, computer repair technician or an automotive technician.

Technologist:

A person who has expertise and knowledge over a broad set of interdisciplinary processes and is able to apply these attributes to solve practical problems with only general direction. A Technologist is expected to contribute to technical designs, process improvements, and documentation as well as assist with analysis. These contributors work under general supervision and document their work which is usually reviewed after completion. Examples include: radiological technologist and laboratory technologist.



Sent Out Surveys!

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- Invited dozens of industry folks to fill out the survey!
- Response – very low!!! (a lot of Sandia MEMS scientists, and a few startups plus our advisory panel members)

What now?

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MANCEF

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We leveraged our friends at MANCEF



Scott Bryant – Executive Director, Steve Walsh, Founding President

Sent out personal invitations to its 200+ members – Superior Response!

MANCEF gave a one year membership to all survey participants!

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Survey Results

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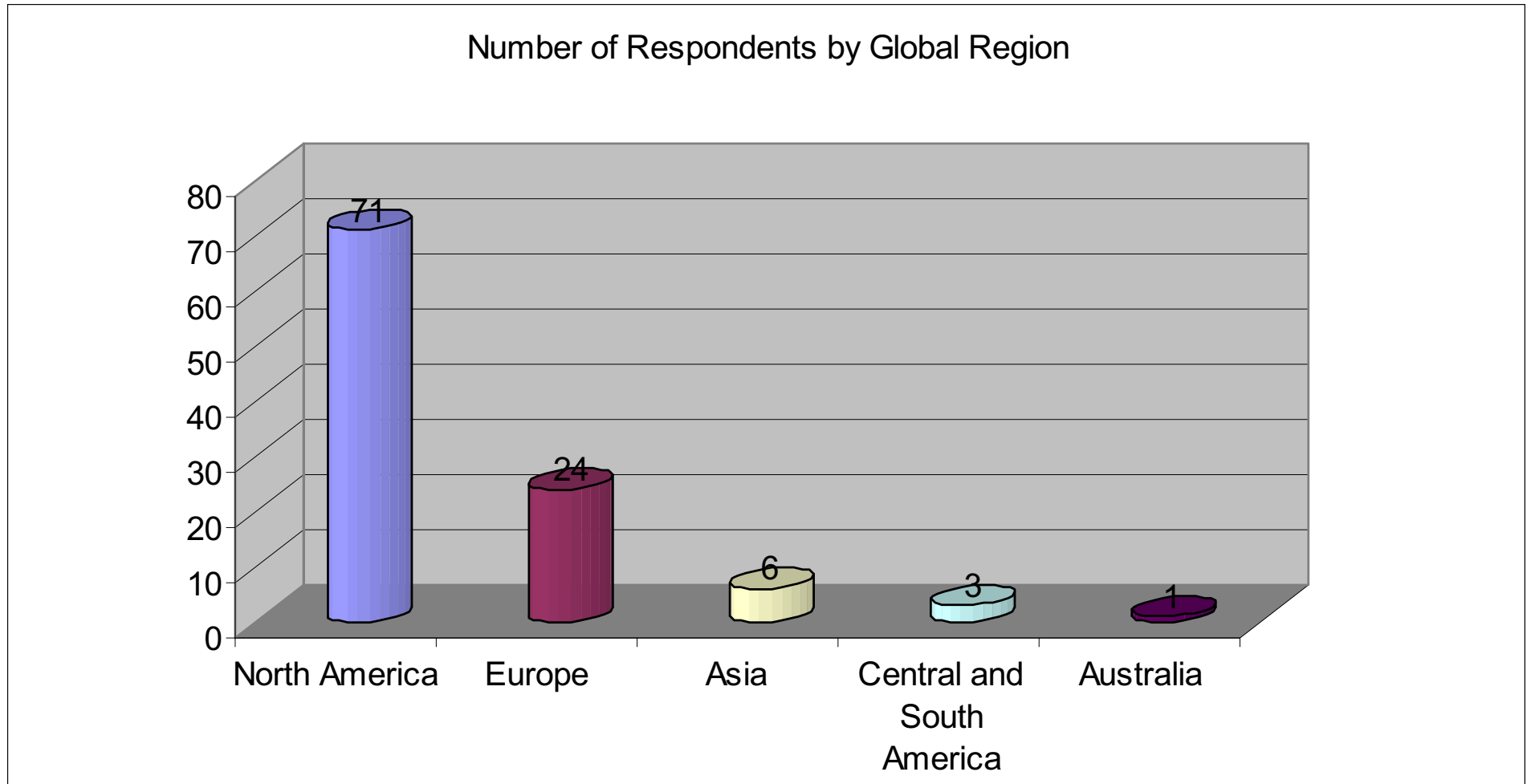
- Respondent Demographics:
 - 106 Respondents
 - 5 Continents Represented
 - 21 US States
 - 85% Male, 15% Female
 - Median Age: 41yrs

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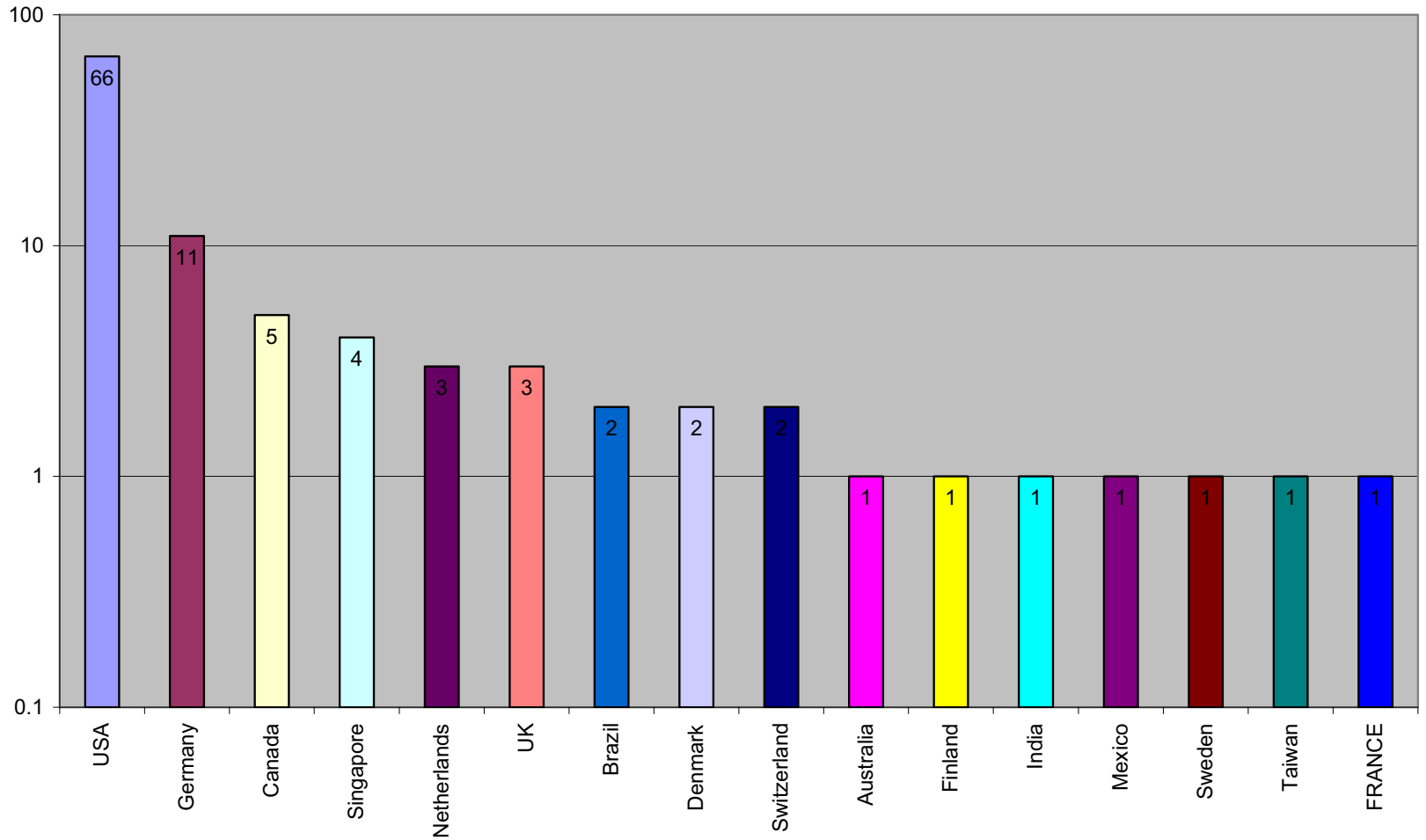
Respondents by Global Region



Top 3: North America, Europe, Asia

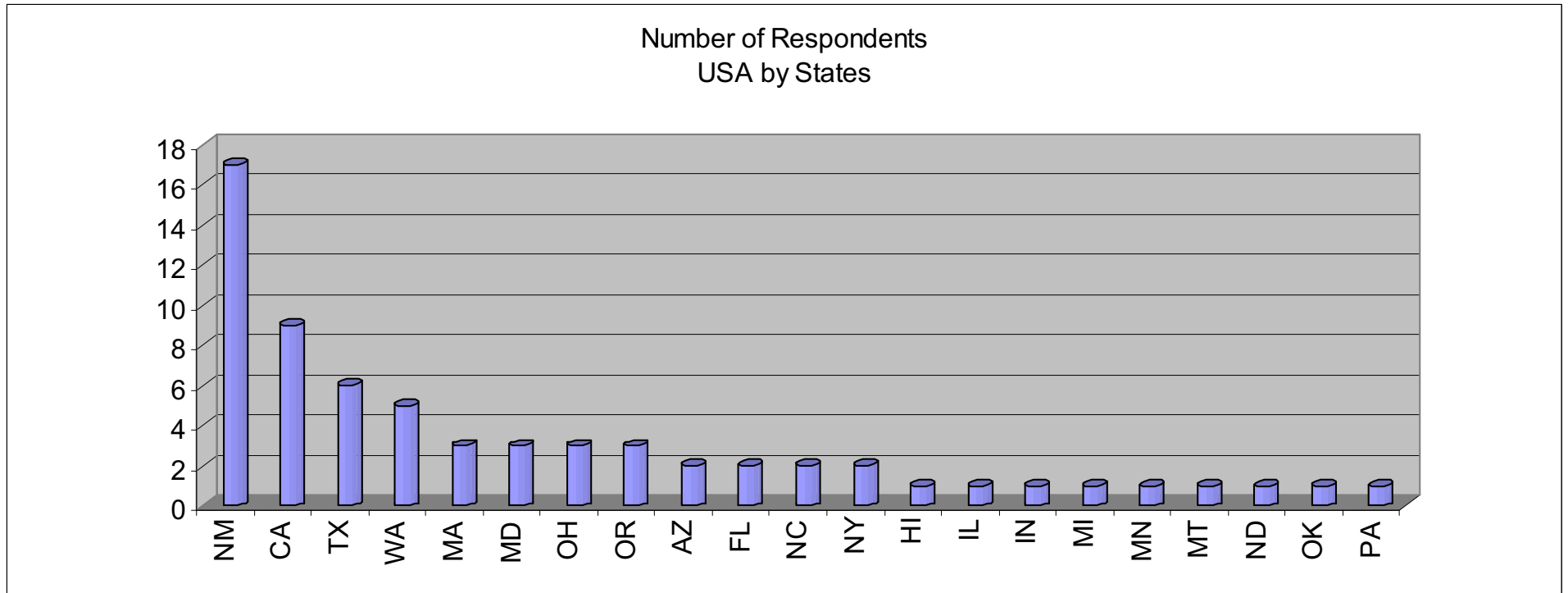
By Country

Number of Respondants by Country



Top 5: USA, Germany, Canada, Singapore

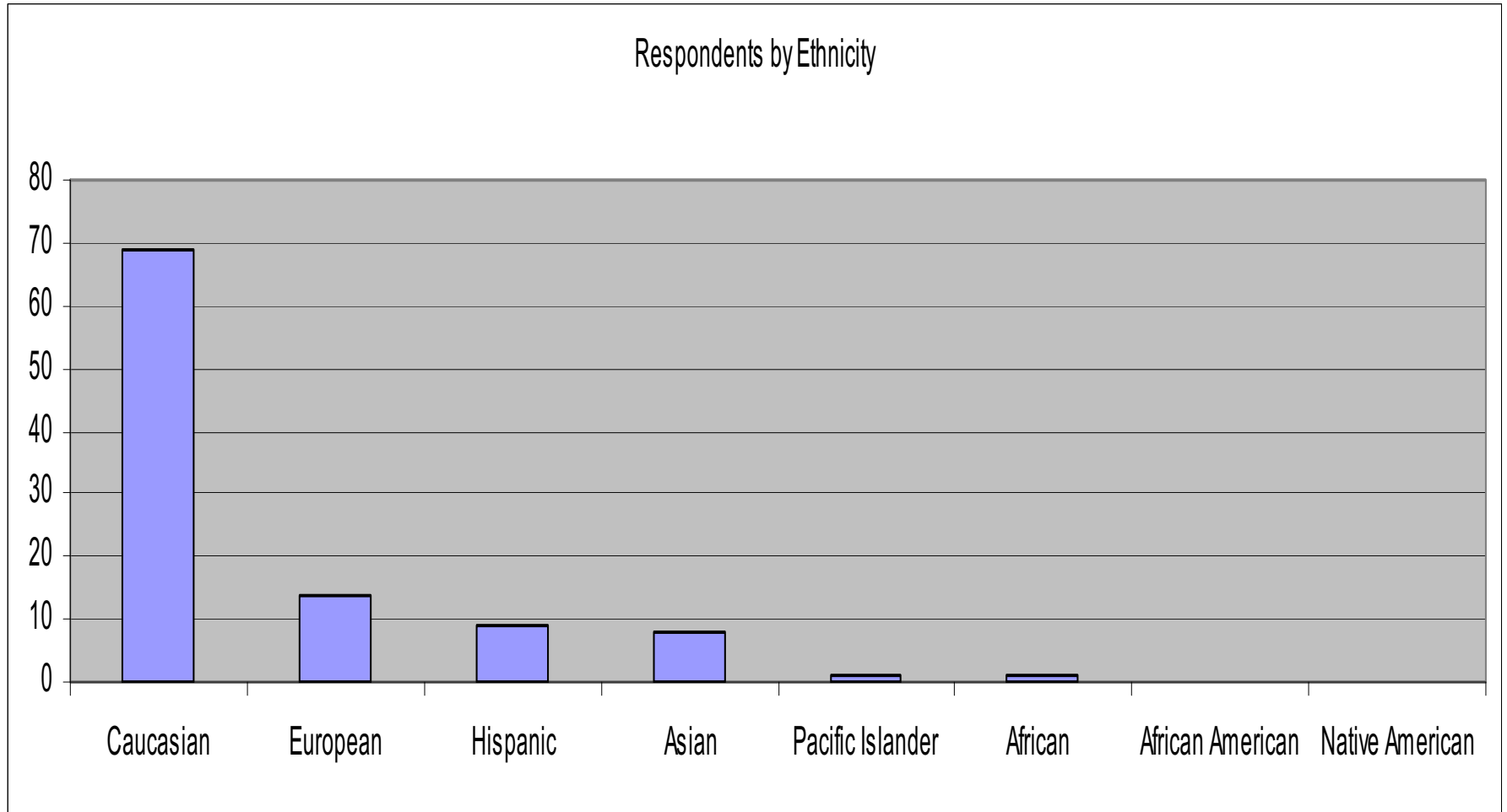
US Respondents by State










Top 5: NM, CA, TX, WA, MA...
We have a regional influence!

Note: New Mexico Ranked #3 in the US by SmallTimes over the last 3 years!

Ethnicity



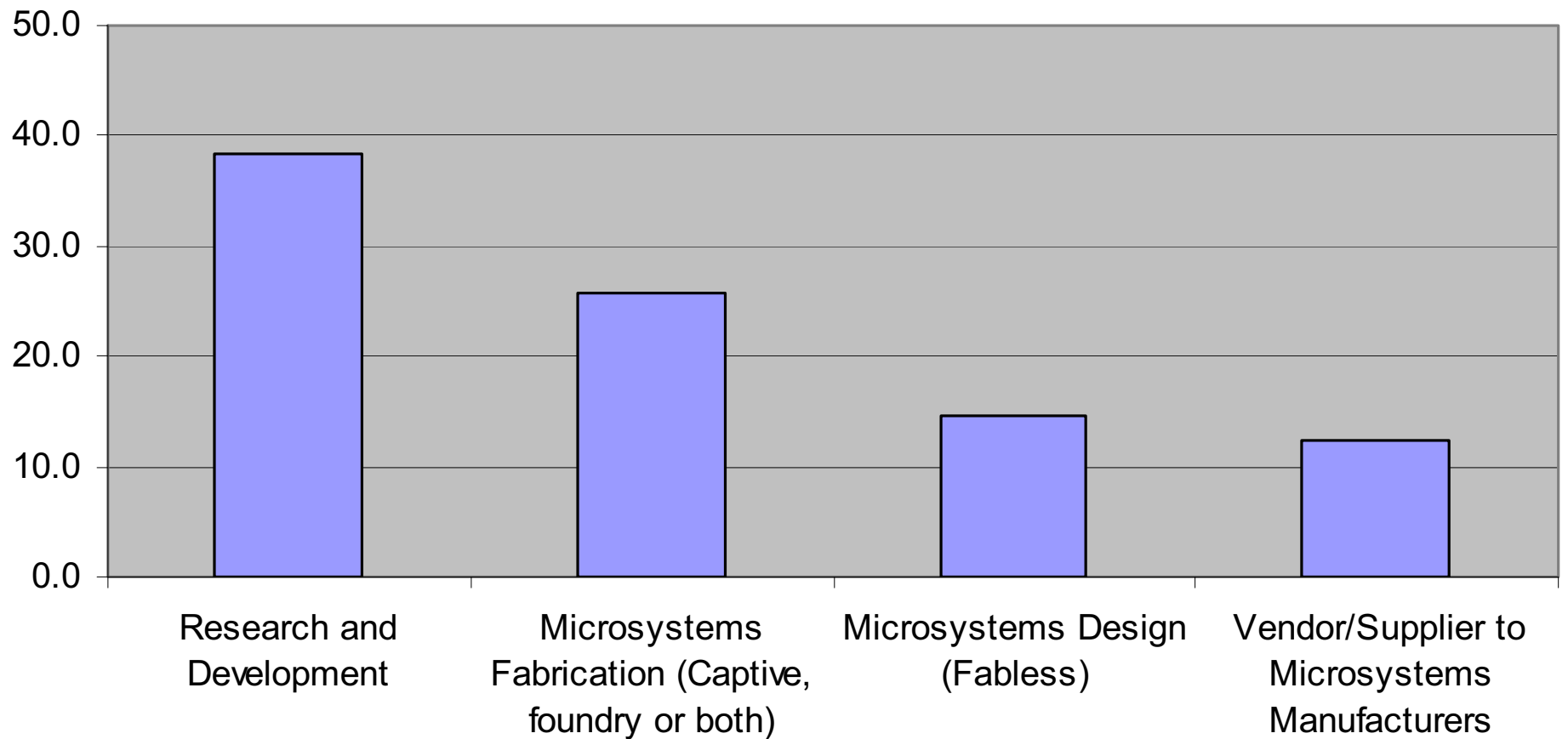
Number of Employees

12. My firm /organization has (check one box):		Number of Responses	Response Ratio
1 to 10 employees.		23	24%
11 to 50 employees.		24	25%
51 to 100 employees.		7	7%
101 to 200 employees.		6	6%
201 to 1000 employees.		14	14%
1001 to 5000 employees.		11	11%
Over 5000 employees.		12	12%
Total		97	100%

Small to Medium Enterprises are 50%










Industry Areas of Activity

Relative Weighted Effort by Industry Activity





MST Applications

Zoomerang

My firm /organization is involved in the following Microsystems applications (check all that apply) :		Number of Responses	Response Ratio
Biological (Sensors, micro-fluidics, in-vivo, in-vitro)		58	60%
Chemical (Sensors, micro-fluidics, micro pumps)		61	63%
Inertial (Micro-gyros, accelerometers, low-g sensors etc.)		48	49%
Micro power		32	33%
Micro switches and relays		44	45%
Micropositioners		22	23%
RF		47	48%
 Other, please specify		40	41%




“Others” included: MOEMS (9%) and Acoustic (6%), Education (9%), Consulting (3%)




IC Vs Non IC Fabrication

My firm /organization works primarily with: (Note : Applies not only to 9. fabrication, but areas of design, research and support.)		Number of Responses	Response Ratio
IC Compatible Processes (i.e., surface micromachining)		58	68%
Non-IC Compatible Processes (i.e., LIGA, bulk ...)		27	32%
Total		85	100%

SMT (Semiconductor Manufacturing Technology)
is still an underlying technology






Feature Size, Aspect Ratio

29. What is the smallest feature size required by your product?		Number of Responses	Response Ratio
less than one half micron		20	27%
between one half and two microns		28	38%
between two and ten microns		15	20%
greater than ten microns		11	15%
Total		74	100%

31. What is the maximum Aspect Ratio (height/depth Vs width/span) required by your product?		Number of Responses	Response Ratio
less than 10:1		20	29%
between 10:1 and 100:1		37	54%
more than 100:1		12	17%
Total		69	100%

More than 70% work in .5um and above and below 100:1 Aspect ratios

Materials Used

33. Check all of the materials you use in your product:		Number of Responses	Response Ratio
Bio Compatible		41	51%
Metals		69	86%
Plastic Based		43	54%
Silicon Based		65	81%
VIEW Additional materials not listed:		24	30%

Design Software

16. Which design software does your firm utilize (check all that apply):		Number of Responses	Response Ratio
AutoCAD		56	67%
CoventorWare		24	29%
Intellisense		7	8%
Internally Developed Design Software		13	16%
SoftMEMS(MEMSCAP's MEMS Pro Software)		10	12%
SUMMIT V (Sandia National Labs IC based surface micromachining)		12	14%
Other, please specify		40	48%

18. In your opinion, which design software package should be used to educate a technologist? Check all that apply		Number of Responses	Response Ratio
AutoCAD		38	52%
SUMMIT V (Sandia IC based surface micromachining) Option 2		14	19%
CoventorWare		29	40%
SoftMEMS (MEMSCAP's MEMS Pro Software)		14	19%
Intellisense		12	16%
Internally Developed Design Software		5	7%
Other, Please Specify		22	30%

We Teach
 -AutoCAD
 -Coventor
 -SUMMIT V

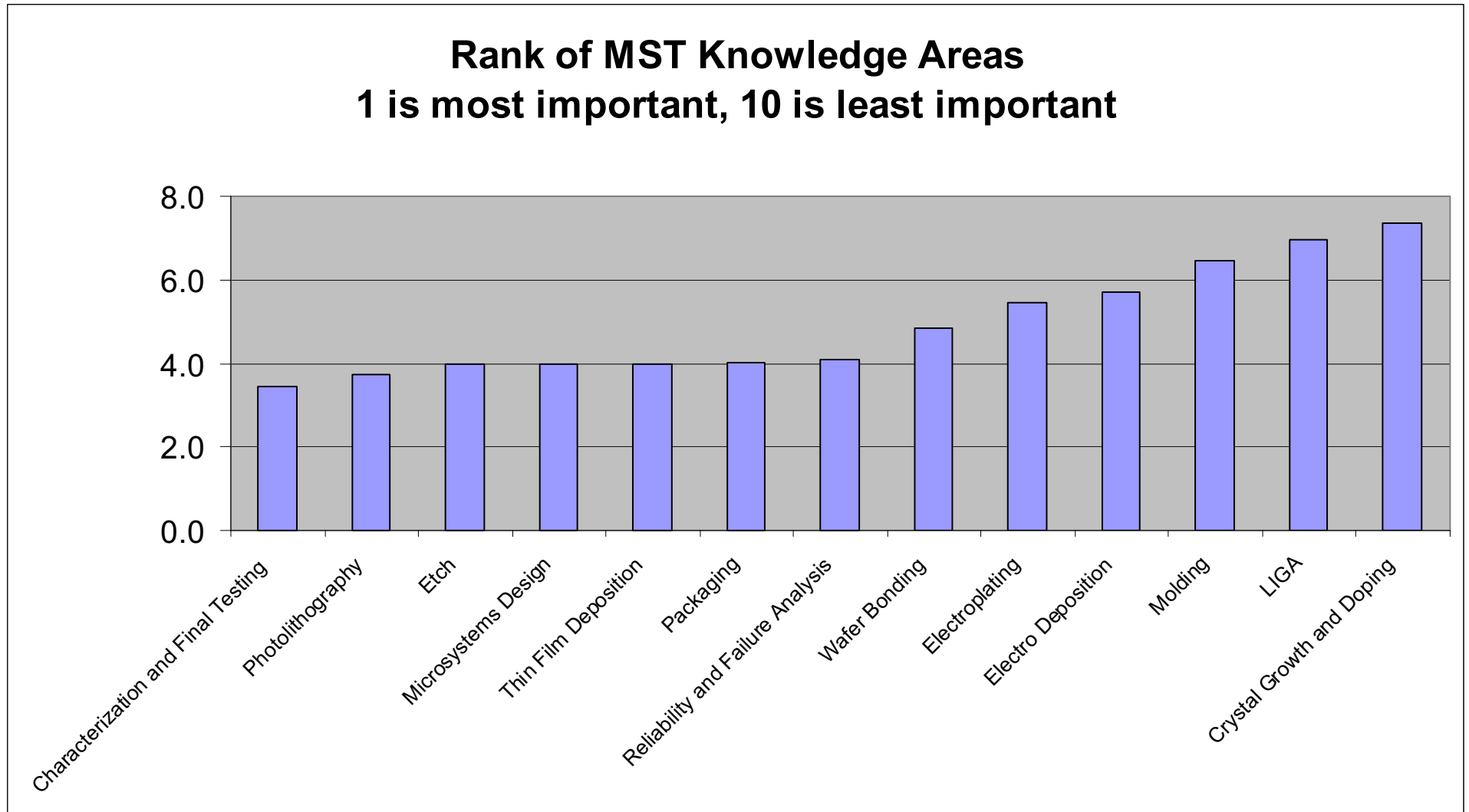
On a scale of 1 to 10, please rank the following Microsystems specific knowledge areas with respect to your organization's technologist needs. (1 being the most important and 10 being the least important, you may **20.** choose to rank several categories with the same value):

<i>The top percentage indicates total respondent ratio; the bottom number represents actual number of respondents selecting the option</i>	1	2	3	4	5	6	7	8	9	10	Don't Know
1. Characterization and Final Testing	35% 27	17% 13	15% 12	6% 5	3% 2	1% 1	3% 2	9% 7	4% 3	5% 4	3% 2
2. Crystal Growth and Doping	4% 3	4% 3	8% 6	4% 3	9% 7	1% 1	1% 1	14% 11	8% 6	36% 27	11% 8
3. Electro Deposition	12% 9	6% 5	12% 9	8% 6	8% 6	10% 8	5% 4	9% 7	12% 9	14% 11	5% 4
4. Electroplating	14% 11	4% 3	12% 9	9% 7	13% 10	8% 6	6% 5	3% 2	9% 7	16% 12	6% 5
5. Etch	31% 24	15% 12	12% 9	1% 1	9% 7	5% 4	4% 3	4% 3	6% 5	9% 7	4% 3
6. LIGA – (German acronym for high aspect ratio x-ray lithography, electroplating and molding).	6% 5	9% 7	4% 3	4% 3	5% 4	8% 6	4% 3	17% 13	8% 6	31% 24	4% 3
7. Microsystems Design	27% 21	14% 11	9% 7	9% 7	9% 7	6% 5	5% 4	10% 8	1% 1	5% 4	3% 2

Screen Shot of Zoomerang Output
Next page for Pareto Graphic ->

Pareto of Previous Data

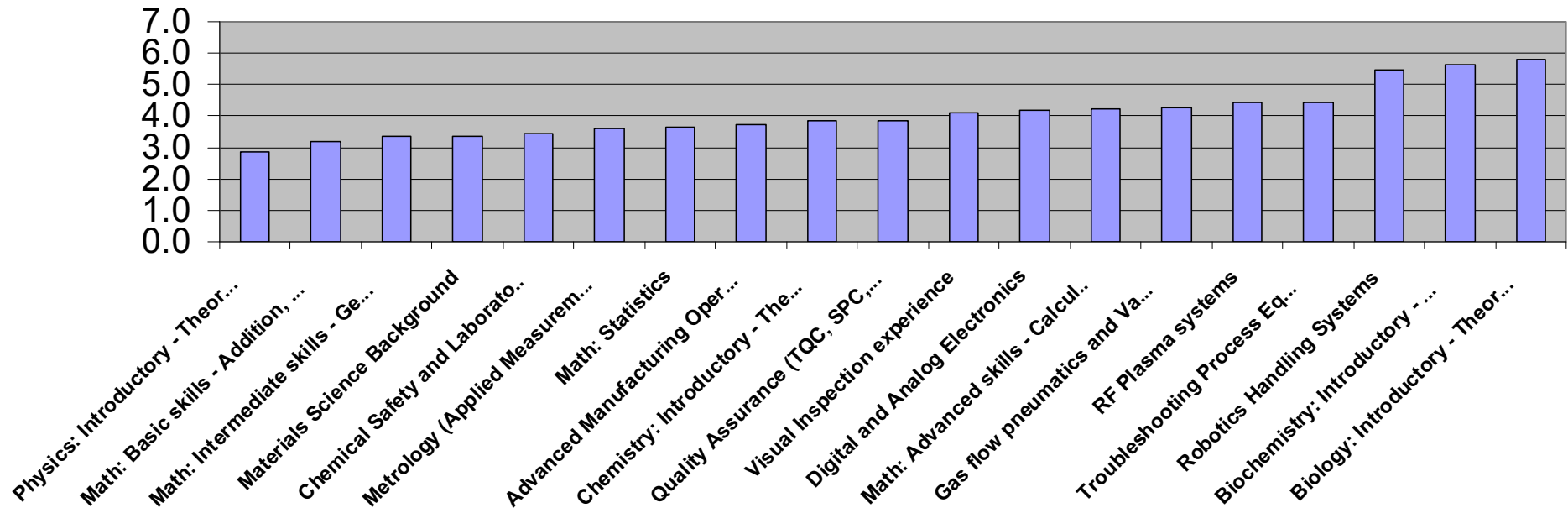
Rank of MST Knowledge Areas
1 is most important, 10 is least important



**Top 5: Characterization & Final Testing,
Photolithography, Etch, Design, Thin Film Dep**

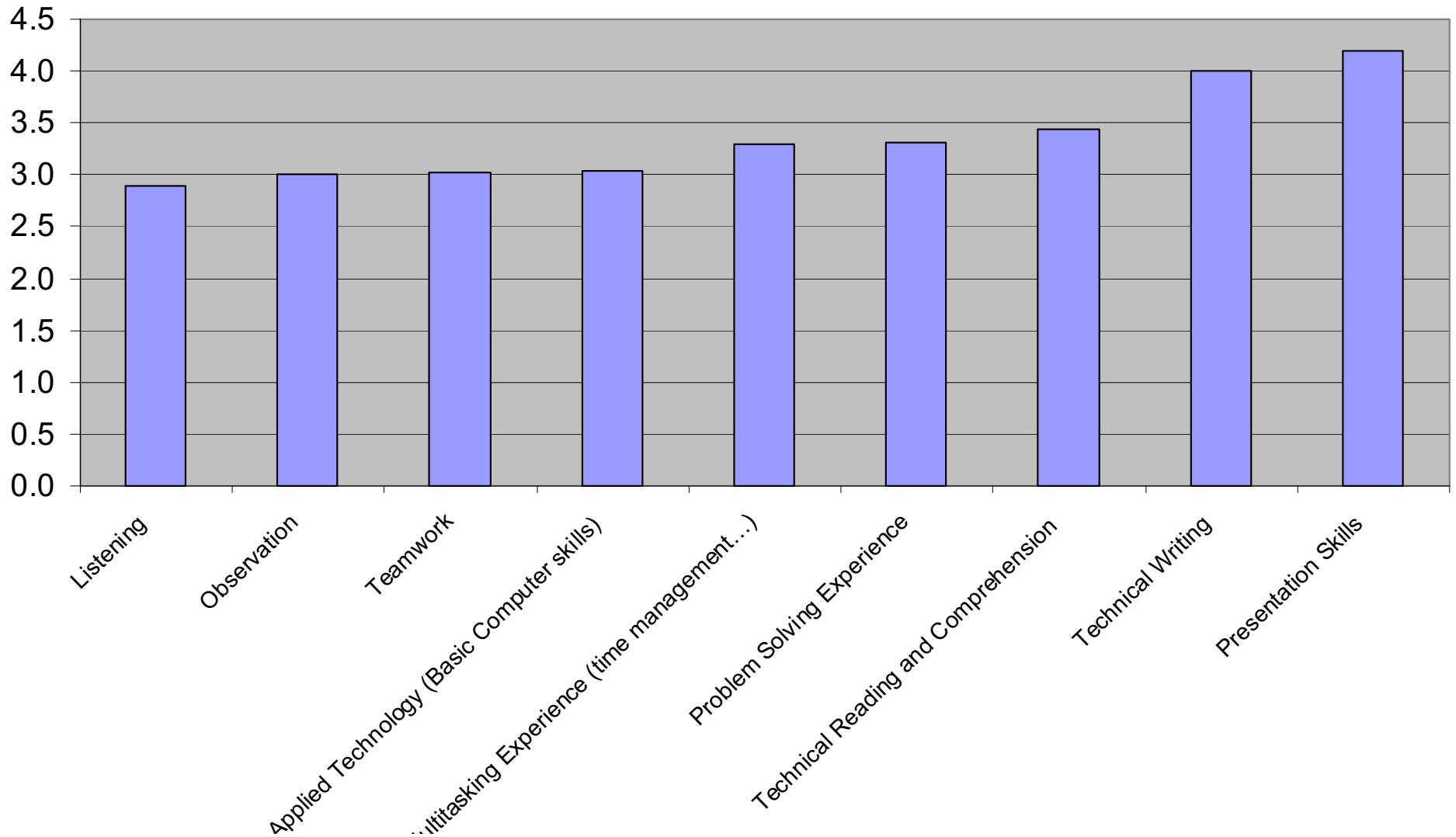
Rank of STEM (Science, Technology, Engineering and Mathematics) Knowledge Areas

1 is most important, 10 is least important



**Top 5: Physics, Basic Math, Intermediate Math,
Material Science, Chemical Safety**

Rank Vs Other Skills and Abilities



**Top 3: Listening, Observation, Teamwork –
WorkKeys Essential Skills**




CC Hiring Practices

35. Are you familiar with the educational programs offered by your local Community Colleges?		Number of Responses	Response Ratio
No		10	12%
Somewhat		35	42%
Yes		39	46%
Total		84	100%

36. Has your firm/organization hired Community College graduates?		Number of Responses	Response Ratio
Yes		44	53%
No		39	47%
Total		83	100%




Most respondents are familiar with their regional CC programs and half have hired CC graduates

Graduate Satisfaction

37. If your firm/organization has hired Community College graduates, are you satisfied with the educational background they bring to the job?		Number of Responses	Response Ratio
No		3	4%
Somewhat		19	28%
Yes		18	27%
Not applicable		27	40%
Total		67	100%

We need to do some work here!

Cross Training Value

Does your firm/organizations value the cross-training of technologists and engineers-to provide a good communications base as well as better understanding of the MEMS/Microsystems design and fabrication process? Is it:		Number of Responses	Response Ratio
Extremely Valuable		31	39%
Valuable		33	42%
Some Value		13	16%
No Value		1	1%
Other, please specify:	VIEW	1	1%
Total		79	100%

Eng/Tech Work Together?

48. How closely do your MEMS/Microsystems engineers and your MEMS/Microsystems technologist work together:		Number of Responses	Response Ratio
None at all		0	0%
Daily		56	79%
At least once a week		5	7%
At least once a month		3	4%
VIEW Other - describe:		7	10%
Total		71	100%

Cross training of Technologists with Engineers is very important
Start at the college level!



Industry Survey Summary

The logo for the Society for Career and Management Education (SCME), consisting of a golden gear-like shape with the letters 'SCME' in red inside.

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- Technologists need to:
 - Have a Global Perspective
 - Be Multi-disciplinary
 - Have a good STEM foundation
 - Have good listening, observation and teamwork skills
- Engineers and Technologists need to be able to work closely together.

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Job Profiling

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WHAT IS **WorkKeys**® ?

A SYSTEM!

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WorkKeys[®] Skill Areas

- Applied Mathematics
- Applied Technology
- Business Writing
- Listening
- Locating Information
- Observation
- Reading for Information
- Teamwork
- Writing



“Virtually every worker in the 21st century will need strong foundations in the eight basic skill sets measured by ACT’s WorkKeys.”

- Richard Judy
Development Director, Workforce
Hudson Institute,
Author of *Workforce 2000* and *Workforce 2020*

9 WorkKeys Skills

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Skill

Skill Level Range

- | | |
|---------------------------|----------|
| • Observing | • 3 to 6 |
| • Locating Information | • 3 to 6 |
| • Listening | • 1 to 5 |
| • Reading for Information | • 3 to 7 |
| • Business Writing | • 1 to 5 |
| • Teamwork | • 3 to 6 |
| • Applied Mathematics | • 3 to 7 |
| • Applied Technology | • 3 to 6 |
| • Writing | • 1 to 5 |

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WorkKeys[®] Approach

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- Objective, standardized data
- Comparable data between occupational/ job profiles and assessment results
- Data is meaningful for both employers and education
- **Focus is on basic, foundation skills needed in most jobs/occupations in today's economy**

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Example: Observation

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Level 6 Characteristics

- Complicated work procedures
- Tasks contain a number of extra details and often involve unusual elements
- Tasks are performed quickly and have a number of steps, but none are highlighted and only some are discussed directly or explained
- There are strong distractions that must be ignored

Level 6 Required Skills

- Recognize a number of steps that are presented at the same time
- Notice and remember several details that are relevant to the procedure
- Visualize how a step fits into the procedure even if there are not many hints or reminders
- Disregard irrelevant info
- Interpret if-then and cause-and-effect relationships that affect tasks
- Make predictions, comparisons and evaluations

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Past vs. Present CTE



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Today's Career Technical Education Graduate must have **lifelong learning skills** as well as essential employability skills in order to remain technically competent and employable

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MEMS Job Profile

Sandia National Laboratory

Data was collected 2005-2006 from two senior Process Technicians.

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WorkKeys Profiling

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WorkKeys job profiling consists of three phases:

- 1) Job shadowing of subject matter experts (SME),
- 2) Meeting with SMEs to complete **comprehensive task list**,
- 3) Meeting with SMEs to determine skill levels.

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Sample from Task List



DRAFT TASK LIST

Sandia Litho/Photo Technologist Task List - TVI Job Profiling 2005/2006

<u>Task</u>	<u>Locating Info</u>	<u>Observation</u>	<u>Reading for Info</u>	<u>Team-Work</u>
129 Reset "blower" that keeps temperature and humidity at proper levels at beginning of shift specific to the area. (Humidity and temperature control).		X		
130 Aligns wafers in boat before putting into microlithography cluster.		X		
131 Answers questions from workers pertaining to procedures and equipment operation.				X
132 Uses EBR (edge bead removal) to clean photo resist off wafer edge.				
133 At inspection phase verifies features are at correct width or if no EBR is required.		X		
134 Check centering, width, solvent splash, encroach on the active die.		X		
135 Reads: manuals, how to manuals for more advanced operations, maintenance manuals, emails. Required company training, a number of online courses required every year, hazcom, radiation training, site specific training, corrosives, safety.	X	X	X	
136 Other areas may be required to assist – detailed communication is therefore required. Offline Rework.		X		X
137 Because some wafers are warped, chuck cleaning is required and recalibrating the spindle motor is required.		X		
138 Works safely to prevent on-the-job injuries by following safety policies and procedures.				X
139 Looks for improvement opportunities – and communicate – verbal with coworkers.		X		X
140 Enters gowning dressing room and puts on clean room bunny suit, shoe covering, additional gloves, face mask, head covering, helmet air filter and checks battery, and safety glasses.		X		



Profile Results

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Skill	Skill Level Range	Entry Skill Level	Experienced Worker Skill Level	No. of Tasks Requiring This Skill	% of Tasks Requiring This Skill
Applied Mathematics	3-7	4	4	19	13%
Applied Technology	3-6	3	3-4	24	16%
Business Writing	1-5	4	4	19	13%
Listening	1-5	3*	5	24	15%
Locating Information	3-6	5	6	64	42%
Observation	3-6	5**	6	135	89%
Reading for Information	3-7	5	5	24	16%
Teamwork	3-6	3***	5	27	18%

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Ranking of Skills



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Most Critical	Observation
	Locating Information
	Listening
	Reading for Information
	Business Writing
	Teamwork
	Applied Technology
Least Critical	Applied Mathematics

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Job Profiling Summary

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- Plethora of data –
 - What Industry Wants is being answered:
 - Which areas are key
 - Technical and STEM Knowledge
 - What Essential Skills are necessary in order to be successful and what skill level must be attained
 - Sandia is considering using elements of this assessment in their promotion and hiring methodologies
 - (WorkKeys is fully EEOC Compliant)

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Summary

The logo for the Society of Community Manufacturers Engineers (SCME), consisting of a glowing orange gear shape with the letters 'SCME' in white inside. A vertical line extends downwards from the gear.

SCME

- Industry Surveys require A LOT OF WORK and support to be successful!
- Surveys can only provide a part of what a Technologist needs to be successful.
- Job Profiling is also extremely valuable!
- The learning from these activities are being incorporated in our educational materials.

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Acknowledgements

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- Special thanks to Sandia National Laboratories:
 - Dale Hetherington – Manager MDL
 - Tina Dallo - Technologist
 - Cristina Gallardo – Technologist
- Our Advisory and NVC Teams
- NSF for your outstanding support!

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Questions?

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You can reach us:

(505) 224-3355

mpleil@cnm.edu

Download the Job Profiling Report and a copy of this presentation:

<http://www.scme-nm.org>

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