The Open Academic Model (OAM) for the Systems Engineering Program at Stevens Institute of Technology

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Introduction

- Demand for qualified system engineers keeps growing – frequent discussion in INCOSE Corporate Advisory Board, steady growth in graduates from US SE graduate programs, US DoD priority
- Universities are a primary means by which government and industry grow their SE talent pool in quality and quantity
- Valuable to understand characteristics of graduate SE university programs in US
- Develop deeper understanding of Stevens SE Program (SSEP) as a case study that could be repeated at other programs

Types of SE Programs in the US

- Two categories of SE programs

  SCSE: Systems Centric SE programs that focus on SE without regard to a specific domain

  DCSE: Domain Centric SE programs in which SE is studied in combination with another domain such as *manufacturing SE* or *biological*

- In early 1980s, there were 22 SE programs in the U.S. (Gasparski 1982)
- In 2010 there were 62 universities offering SE graduate programs; 33 of them offer SCSE graduate programs (Fabrycky 2010)

SCSE and DCSE Degree Programs

Degrees	BS		MS		PhD		Total	
	2005	2010	2005	2010	2005	2010	2005	2010
Exclusively SE (SE Centric)	11	11	27	31	10	14	**48**	**56**
SE engineering is combined with some other disciplinary specialty (Domain Centric)	32	44	36	42	14	23	**82**	**109**
Total	**43**	**55**	**63**	**73**	**24**	**37**	**130**	**165**

- SCSE BS did not grow, MS grew 15%, PhD 40%, Total 17%
- DCSE BS grew 38%, MS 17%, PhD 64%, Total 33%

US Universities With SCSE Programs Started 2005 or Earlier

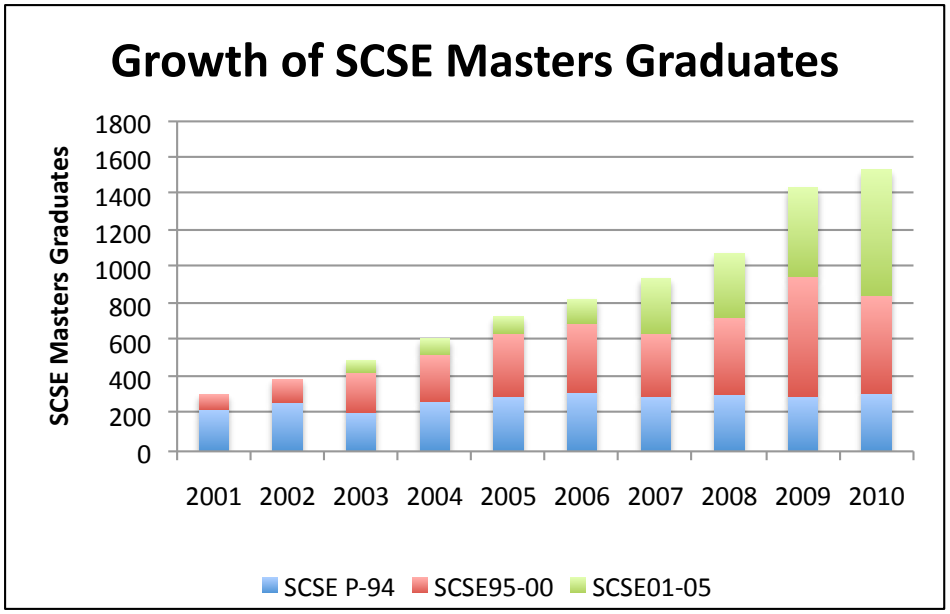
1. *Air Force Institute of Technology*	16. *Rochester Institute of Technology*
2. *Boston University*	17. *Stevens Institute of Technology*
3. *Case Western Reserve University*	18. *Southern Methodist University*
4. *Cornell University*	19. *Southern Polytechnic State University*
5. *George Mason University*	20. *University of Alabama – Huntsville*
6. *George Washington University*	21. *University of Arizona*
7. *Iowa State University*	22. *University of Houston - Clear Lake*
8. *Johns Hopkins University*	23. *University of Idaho*
9. *Lehigh University*	24. *University of Pennsylvania*
10. *Massachusetts Institute of Technology*	25. *University of Maryland*
11. *Missouri university of Science and Technology*	26. *University of Southern California*
12. *Naval Postgraduate School*	27. *University of Texas – Arlington*
13. *Polytechnic University – Farmingdale*	28. *University of Virginia*
14. *Penn State at Great Valley*	29. *Virginia Tech*
15. *Portland State University*	30. *Washington University*

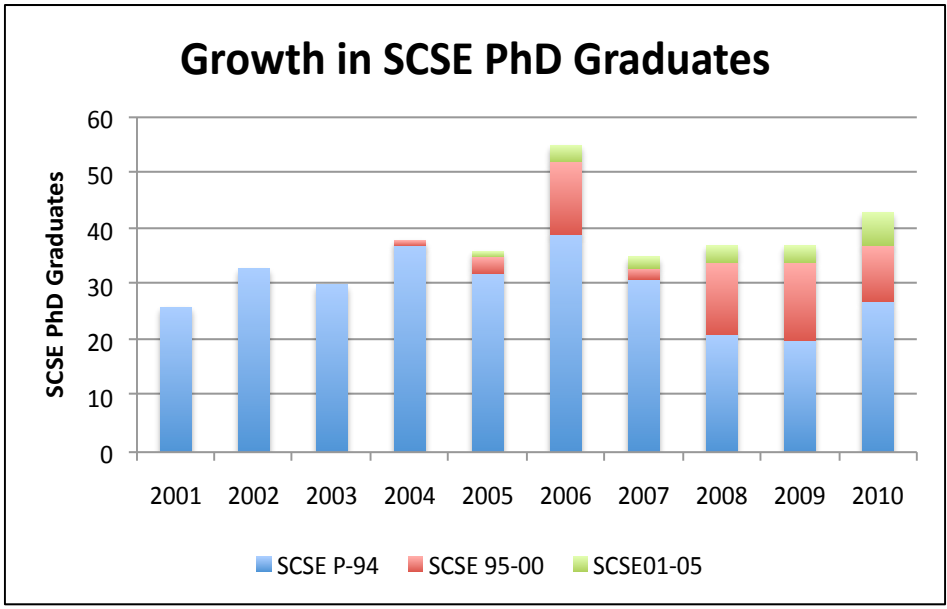
Categorizing SCSE Graduate Programs That Started in 2005 or Earlier

	SCSE P-95	SCSE 95-00	SCSE 01-05
MS	13	9	7
PhD	8	3	1

Growth in Graduates of SCSE Programs

Annual Master's and Doctorate Graduates





2001-2010; Stevens #4 overall

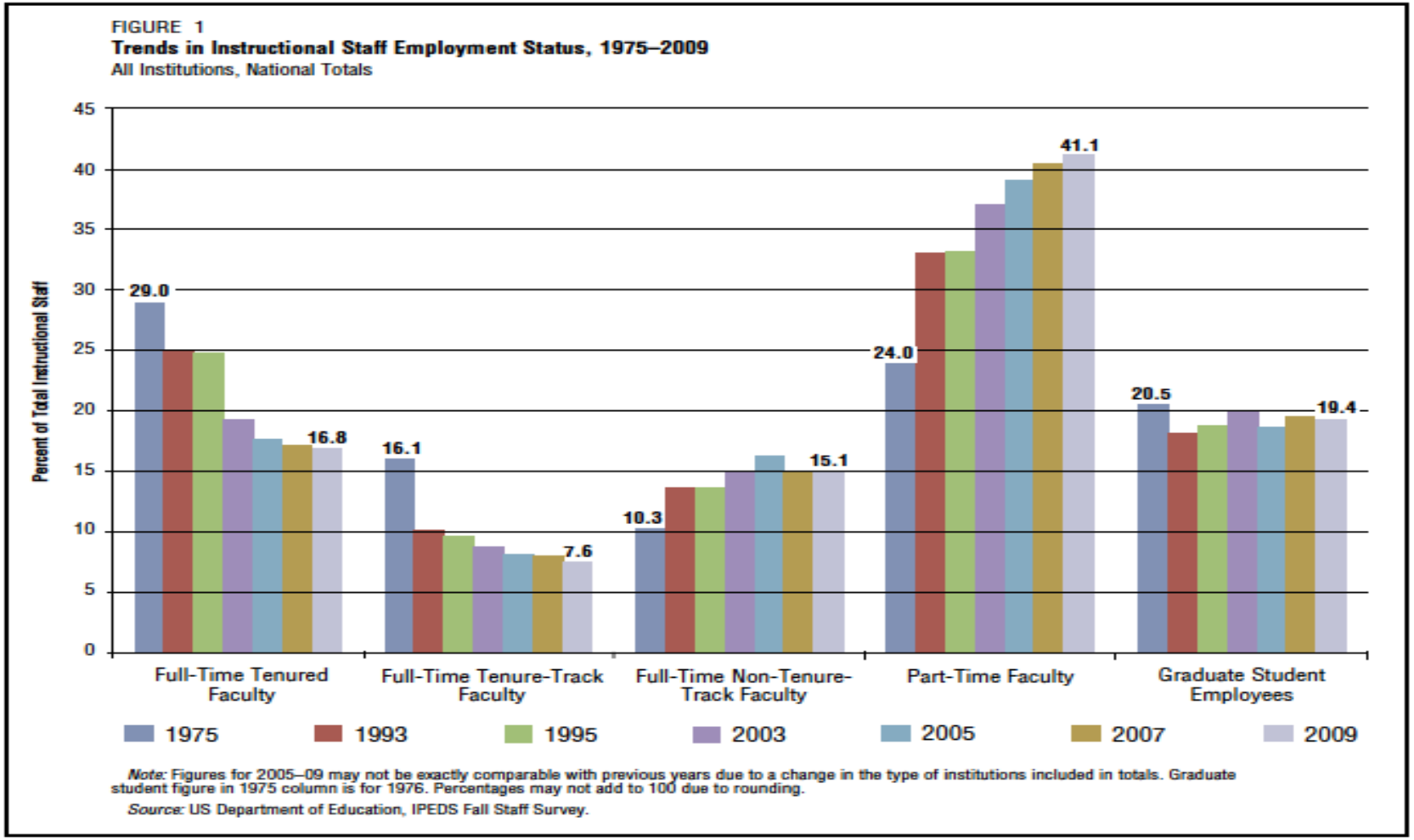
- Almost no growth in older master's programs; rapid growth in new programs; 51% of all graduates produced by top 6 programs
- Doctoral graduates fairly level – 353 from 2001-2010; older programs dominate with 84% of graduates

Categ-ory	Institution	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Sum	% By Category	% Total Degrees
P-94	1	15	16	14	4	10	10	7	7	7	6	96	3%	1%
P-94	2	26	40	32	39	41	36	45	25	24	49	357	13%	4%
P-94	3	41	43	45	70	61	71	50	62	47	63	553	20%	7%
P-94	4	49	47	33	31	34	48	57	66	60	54	479	17%	6%
P-94	5	2	0	1	1	4	5	3	5	2	5	28	1%	0%
P-94	6	31	27	18	12	19	18	22	17	10	14	188	7%	2%
P-94	7	17	29	16	35	32	24	32	37	21	24	267	9%	3%
P-94	8	4	5	4	4	1	2	4	6	1	1	32	1%	0%
P-94	9	18	39	26	30	23	24	23	16	38	27	264	9%	3%
P-94	10	11	4	9	5	5	3	4	9	5	4	59	2%	1%
P-94	11	1	1	1	1	0	0	5	1	0	6	16	1%	0%
P-94	12	2	4	4	20	46	50	29	37	26	26	244	9%	3%
P-94	13	10	12	10	18	21	29	16	23	56	36	231	8%	3%
P-94	**Total**	**227**	**267**	**213**	**270**	**297**	**320**	**297**	**311**	**297**	**315**	**2814**	100%	34%
	%Growth		**1**	**-2**	**27**	**10**	**8**	**-7**	**5**	**-5**	**6**			
95-00	1	11	12	14	15	73	107	93	76	67	67	535	16%	6%
95-00	2	26	41	65	66	94	105	88	89	134	100	808	24%	10%
95-00	3	4	9	39	12	6	16	11	18	25	26	166	5%	2%
95-00	4	2	3	3	2	3	0	0	0	1	0	14	0%	0%
95-00	5	10	13	20	58	73	58	66	117	307	191	913	27%	11%
95-00	6	27	16	23	14	15	8	2	1	3	11	120	4%	1%
95-00	7	0	13	12	35	19	24	21	18	14	27	183	5%	2%
95-00	8	0	2	17	17	22	21	20	37	38	44	218	6%	3%
95-00	9	5	18	26	37	43	41	47	61	67	68	413	12%	5%
95-00	**Total**	**85**	**127**	**219**	**256**	**348**	**380**	**348**	**417**	**656**	**534**	**3370**	100%	40%
	%Growth		**49**	**72**	**17**	**36**	**9**	**-8**	**20**	**57**	**-19**			
01-05	Stevens			12	38	41	48	68	52	142	269	670	30%	8%
01-05	2			39	44	34	53	65	97	88	92	512	23%	6%
01-05	3						8	138	190	237	301	874	40%	10%
01-05	4			7	0	5	4	0	1	3	8	28	1%	0%
01-05	5						6	6	7	2	5	26	1%	0%
01-05	6			8	5	11	12	17	3	8	6	70	3%	1%
01-05	7						0	6	4	5	5	20	1%	0%
01-05	**Total**			**66**	**87**	**91**	**131**	**300**	**354**	**485**	**686**	**2200**	100%	26%
	%Growth				**32**	**5**	**44**	**129**	**18**	**37**	**41**			
Grand Total	**Total**	**312**	**394**	**498**	**613**	**736**	**831**	**945**	**1082**	**1438**	**1535**	**8384**		100%
	%Growth		**26**	**26**	**23**	**20**	**13**	**14**	**14**	**33**	**7**			

Category	Institution	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Sum	% By Category	% Total Degrees
P-94	1	2	4	2	3	6	9	7	NA	NA	NA	33	11%	9%
P-94	2	4	2	6	13	3	7	7	7	2	6	57	19%	16%
P 94	3	3	3	2	0							8	3%	2%
P-94	4	7	7	4	1	6	7	6	6	8	8	54	18%	15%
P-94	5	4	4	7	5	3	4	1	7	2	0	37	13%	10%
P 94	6	3	4	4	9	6	6	6	6	5	6	55	19%	16%
P-94	7		5	2	1	8	0	0	1	1	3	21	7%	6%
P-94	8	3	4	3	5	0	6	4	0	2	4	31	10%	9%
P-94	**Total**	26	33	30	37	32	39	31	21	20	27	**296**	100%	84%
	%Growth		27	-9	23	-14	22	-21	-32	-5	35			
95-00	1	0	0	0	0	0	0	0	0	0	10	10	26%	3%
95-00	2	1	2	2	2	4	5	4	5	1	1	27	69%	8%
95-00	3	0	0	0	0	0	0	0	2	0	0	2	5%	1%
95-00	**Total**	1	2	2	2	4	5	4	7	1	11	39	100%	11%
	%Growth		100	0	50	133	157	67	200	-17	27			
01-05	Stevens					1	3	2	3	3	6	18	100%	5%
01-05	**Total**	0	0	0	0	1	3	2	3	3	6	18	100%	5%
	%Growth						200	-33	50	0	100			
Grand Total	**Total**	**27**	**35**	**32**	**39**	**37**	**47**	**37**	**31**	**24**	**44**	**353**		**100%**

Faculty Characteristics in SCSE Programs

Full-Time US Non-Tenure Track Faculty (NTTF)



Factors in the Decline of TTTF in the US

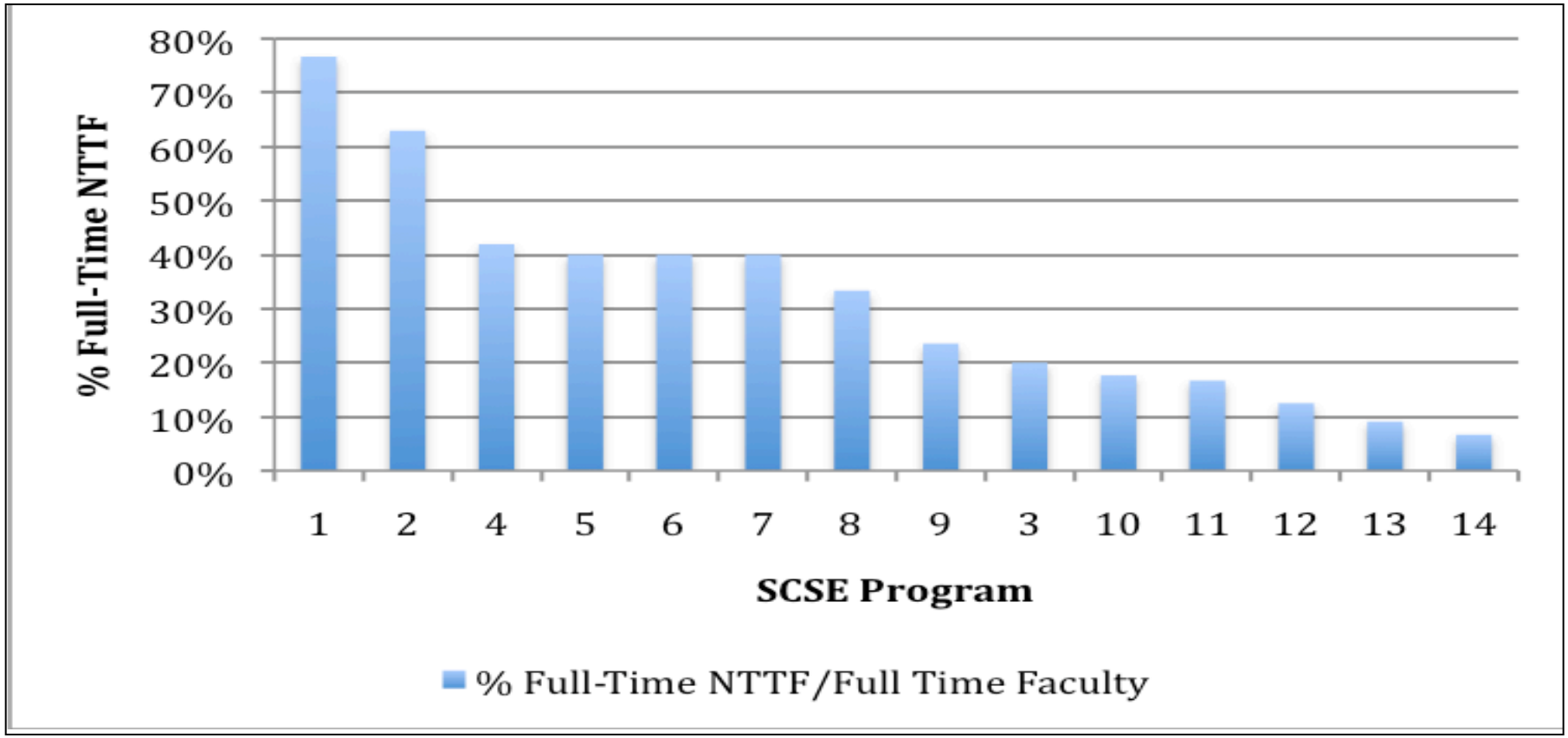
- **Cost savings**: full-time NTTF on average, receive lower salaries and benefits combined with limited professional support than TTTF.

  can hire more or less full-time NTTF much more readily than TTTF.

- **Governance**: TTTF play a larger role in university governance than full-time NTTF.

- **Flexibility**: As enrollments fluctuate, colleges

Full-time NTTF in SCSE Programs



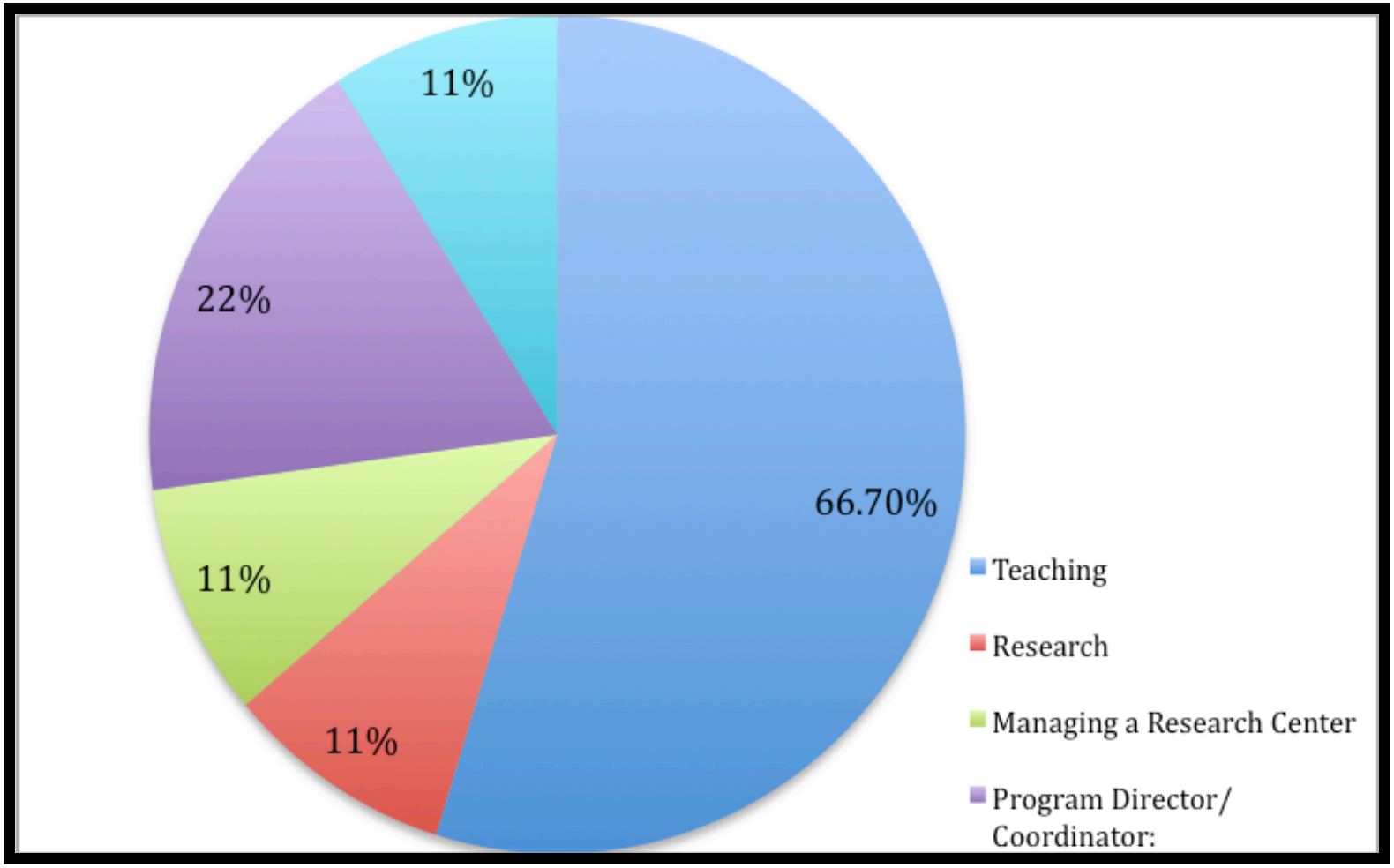
< 50% of SCSE hire full-time NTTF

65% have <= 4 full time NTTF

Motivation to Hire SCSE Full-time NTTF

Reasons for Hiring full-time NTTF	Response Rate
Industry experience	**100%**
Managerial experience	30%
Teaching effectiveness	30%
Flexibility to meet short-term needs	10%
Provide release time to TTTF to conduct their research	30%
Other: domain knowledge in non-traditional areas (creativity, social networks, etc.)	10%

Main Duties of SCSE Full-time NTTF



Full-time NTTF Policies and Duties

Duty	Yes	No	Do not know
Participate in governance at the institutional level	82%	14%	4%
Participate in governance at the department/program level	82%	4%	14%
Have opportunities to assume administrative leadership roles	86%	10%	4%
Have opportunities to assume leadership roles in research	86%	0%	14%
Participate in course/curriculum development and updates	86%	0%	14%
Have opportunities for professional development similar to those available to TTF	86%	10%	4%
Have opportunity to change from NTTF to TTF position.	76%	10%	14%
Have opportunities for promotions and career ladder advancement	82%	18%	0%
Have full time benefits coverage similar to that of TTF	90%	10%	0%
Advise students (undergraduate, masters, and PhD)	68%	18%	14%
Be members of PhD student committees even if they are not allowed to be advisors	73%	4%	23%
Be hired as regular full time employees	91%	5%	4%
Be hired as independent contractors	14%	62%	24%

Comparison of Roles of SCSE Full-time NTTF and TTTF

- 75% of full-time faculty at responding SCSE programs are TTTF.
- TTTF are generally more active in research than full-time NTTF (publications and research funding).
- 70% indicated that TTTF received higher teacher effectiveness ratings from students than full-time NTTF.
- There is not a large difference in teaching load between full-time NTTF and TTTF.
- TTTF consistently have a higher administrative load than full-time NTTF.

Barriers to Hiring and Retaining SCSE Full-Time NTTF

- Limited budget to hire full-time NTTF
- Full-time NTTF are viewed by some TTTF as an attempt to build an alternate track
- NTTF typically year-to-year contracts, sometimes with limited opportunity to renew beyond 3 to 5 years
- Requirements for full-time NTTF to be self-funded, i.e. having to get their own grants
- Pressure to build research programs via traditional TTTF hiring
- Policies limiting the number of full-time NTTF

Open Academic Model

OAM Definition

- Since 2001, SSEP created and adopted OAM to guide its strategic planning towards achieving its mission.

- OAM is defined through its five interdependent principles along with the strategies adopted to implement them.

OAM Principles

1. *Broad Partnerships – Continuously ally with industry, government, and academic partners to produce and leverage the best education and research quality*

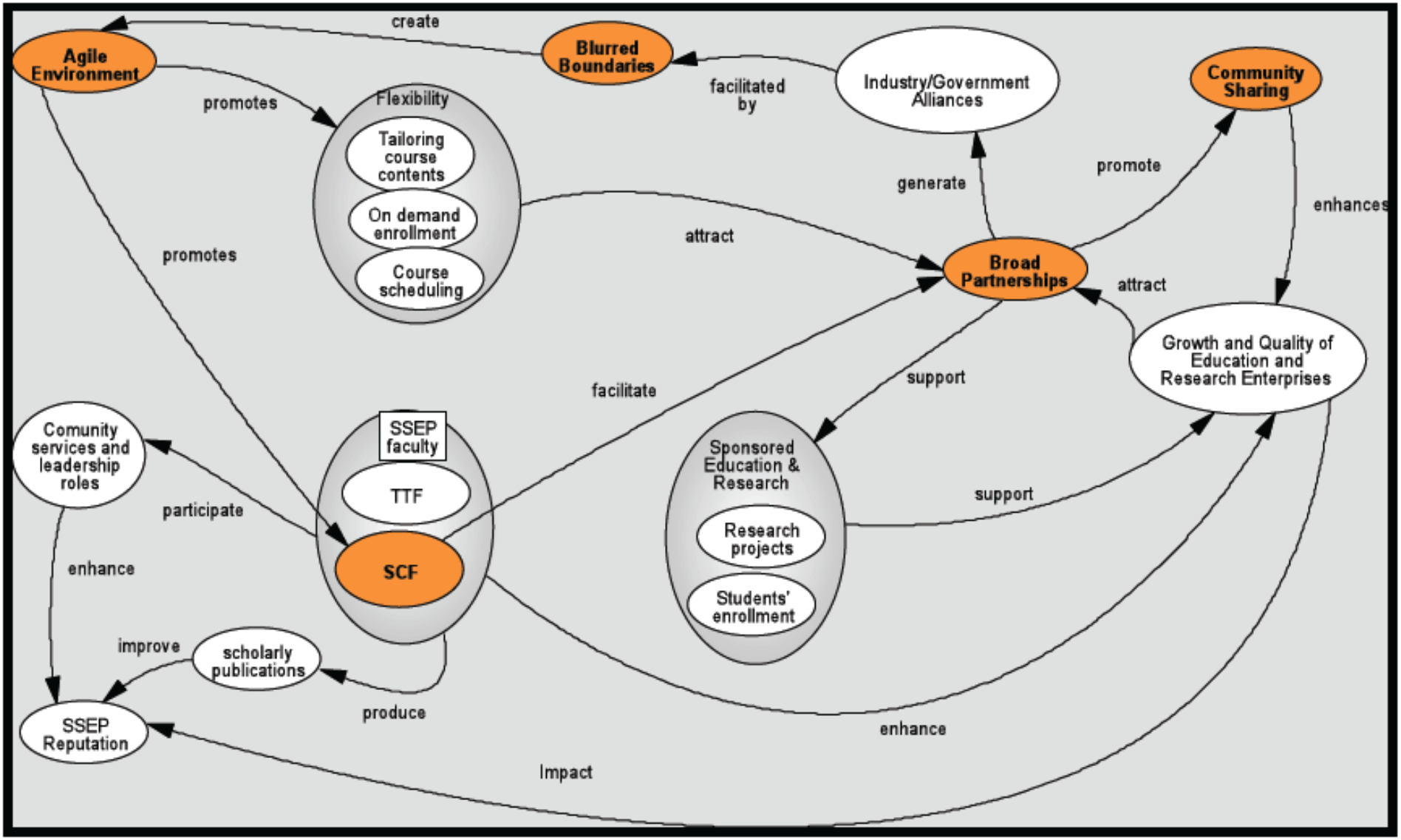
2. *Blurred Boundaries – Blur the boundaries between the academic setting and those of industry and government by bringing industry and government reality into academia in education and research and providing the results of academic research to industry and government;*

3. *Agile Environment*– Promote an education and research environment that is responsive to changing environments and emerging opportunities;

4. *Community Sharing* – Develop high-quality educational and research material and make it available to SSEP community, while promoting open sharing and collaboration;

5. *Second Career Faculty (SCF)* – Adopt non-traditional methods of hiring and retaining high-quality faculty by embracing candidates from industry and government who align well with the strategic goals of SSEP and have the academic qualifications to contribute to the program.

OAM Principles



Metrics to Evaluate SSEP Impact

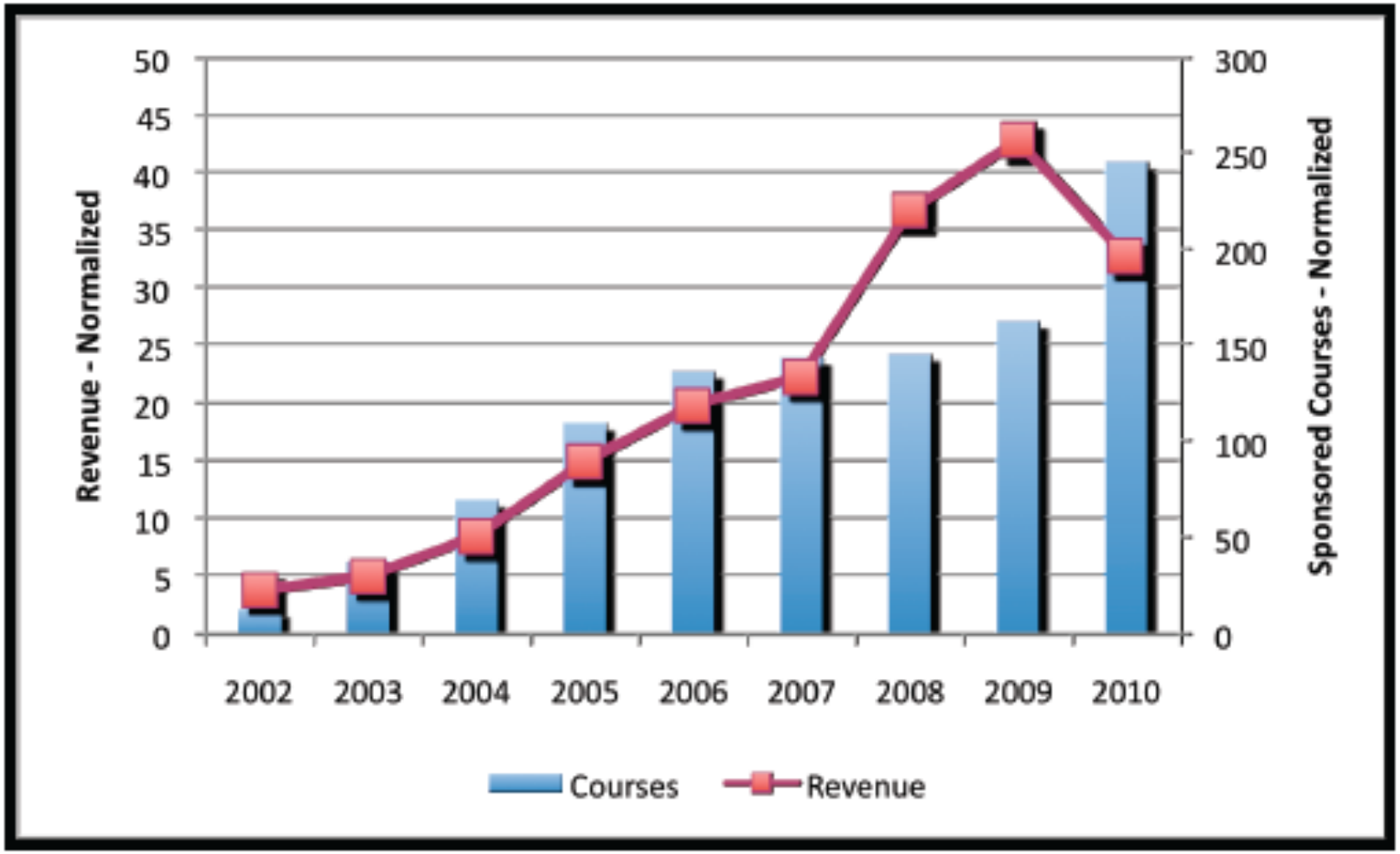
Size: steady growth in the number of students, faculty, revenue, and sponsors

Quality: ratings by students and sponsors/partners of the educational and research programs within the last decade. Ratings are based on Kirkpatrick Levels 1 (student reaction), 3 (behavior), and 4 (results in application) (Kirkpatrick, 2009)

Publications (Scholarship): steady growth in the absolute number and top-tier per capita number of peer-reviewed journal publications and books.

Service Leadership: steady growth in the absolute number of SSEP faculty leadership roles in the systems engineering community outside Stevens and per capita leadership roles compared to that of other leading SE programs.

Size: Growth in Revenue and Course Offerings



Quality: Kirkpatrick Quality Levels

Level 1: How student reacts to course

Level 3: Impact that learning has on job performance

Level 4: Impact that learning has on business measures – ROI

Data Collected for Kirkpatrick Levels

Level 1: How students reacts to course

- Student feedback (course evaluations) for the period 2001-2010, including feedback on course content, teaching effectiveness, and delivery format

Level 3: Impact that learning has on job performance

- Alumni and sponsors' feedback on the change in job behavior of employees after graduation

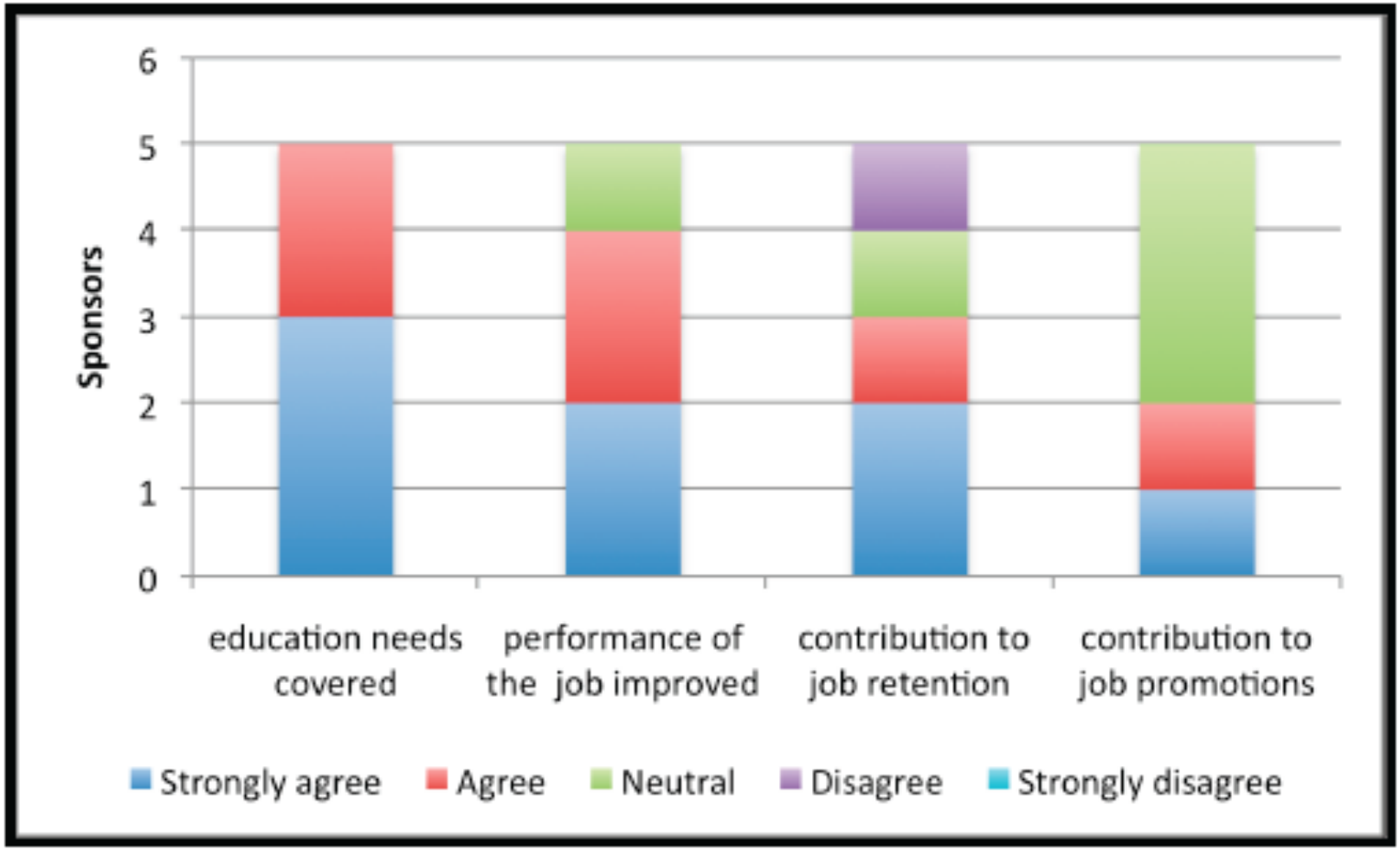
Level 4: Impact that learning has on business measures - ROI

- Executives from sponsors provide feedback for the period 2001-2010 related to SE graduate education from Stevens and its impact on the organization's business

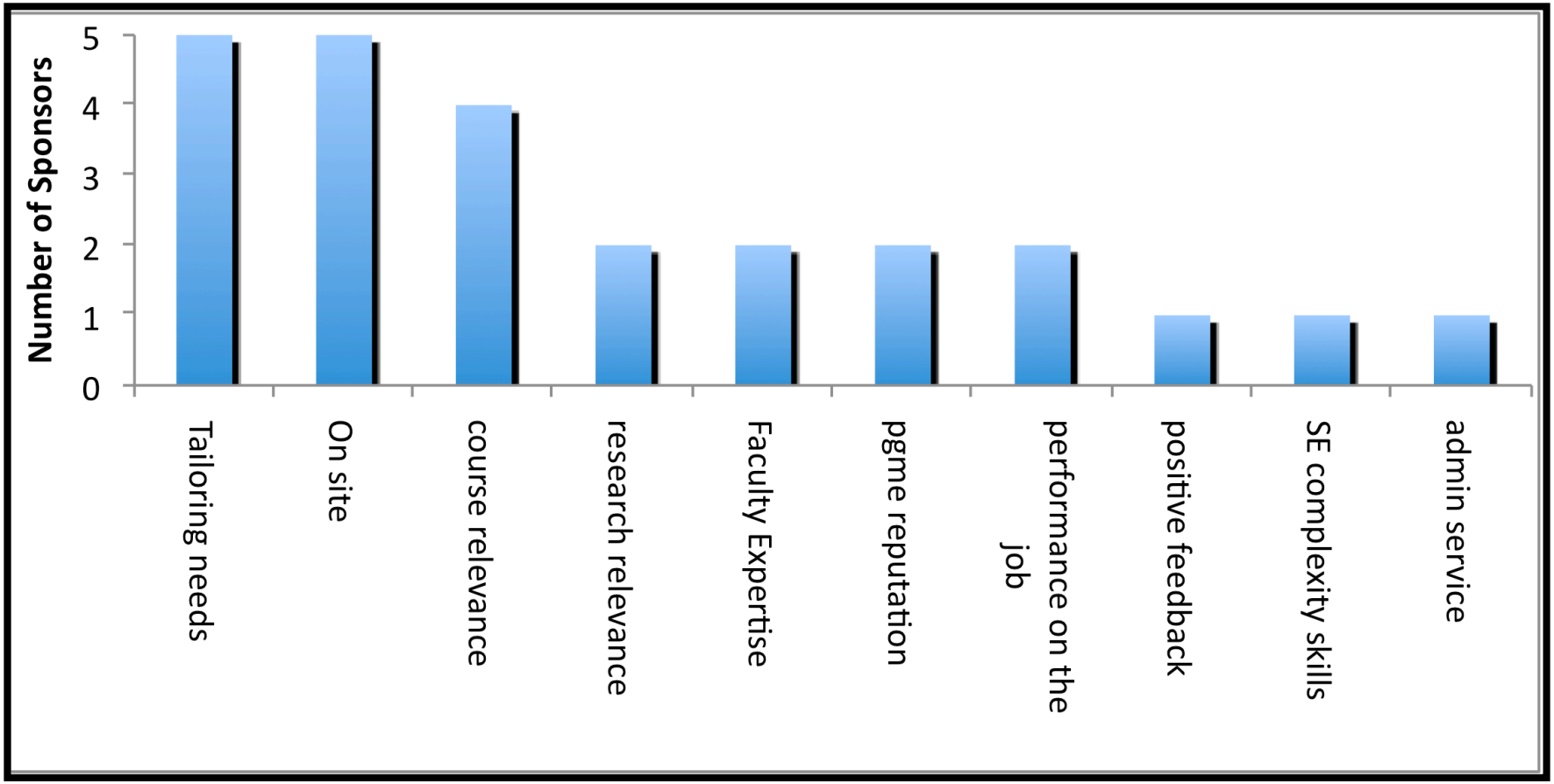
Level 1 Data for 2004 from 200 Students from 4 Sponsors

- >80% strongly agree/agree instructor is effective
- >80% strongly agree/agree course is excellent, useful, and applicable to job
- >70% strongly agree/agree will enhance career objectives

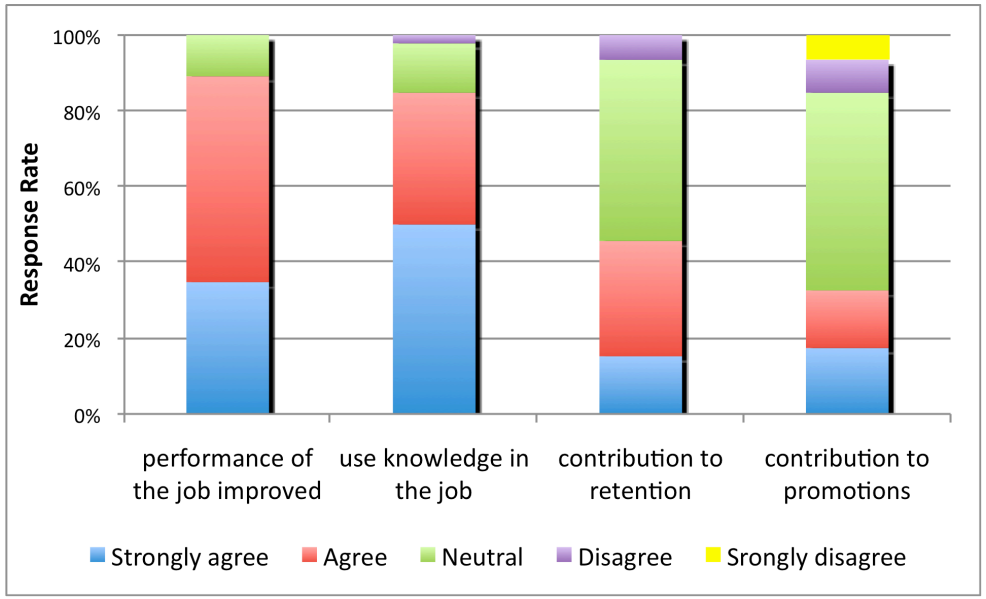
Kirkpatrick Level 3 - Sponsor Executives Survey Response

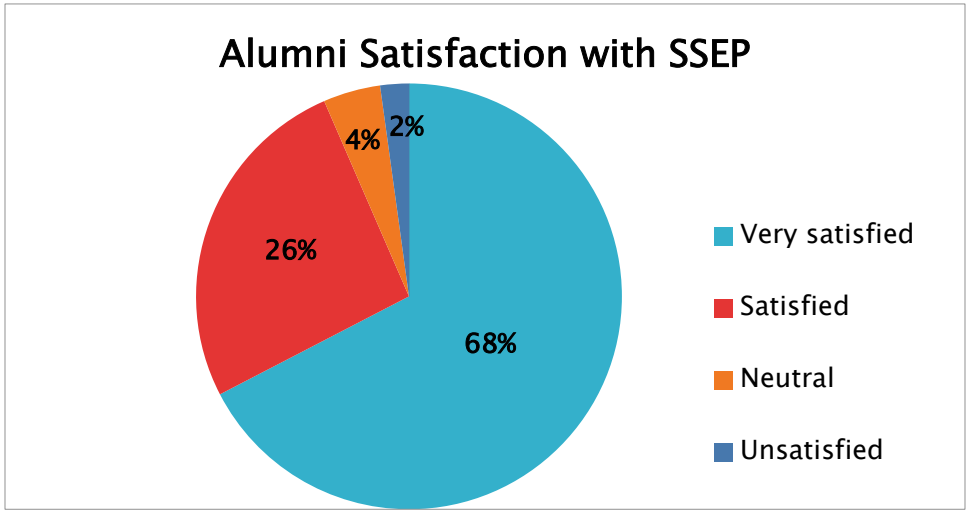


Kirkpatrick Level 3 – More Executive Responses On What Provided Impact



Kirkpatrick Level 3 – Alumni Survey Response



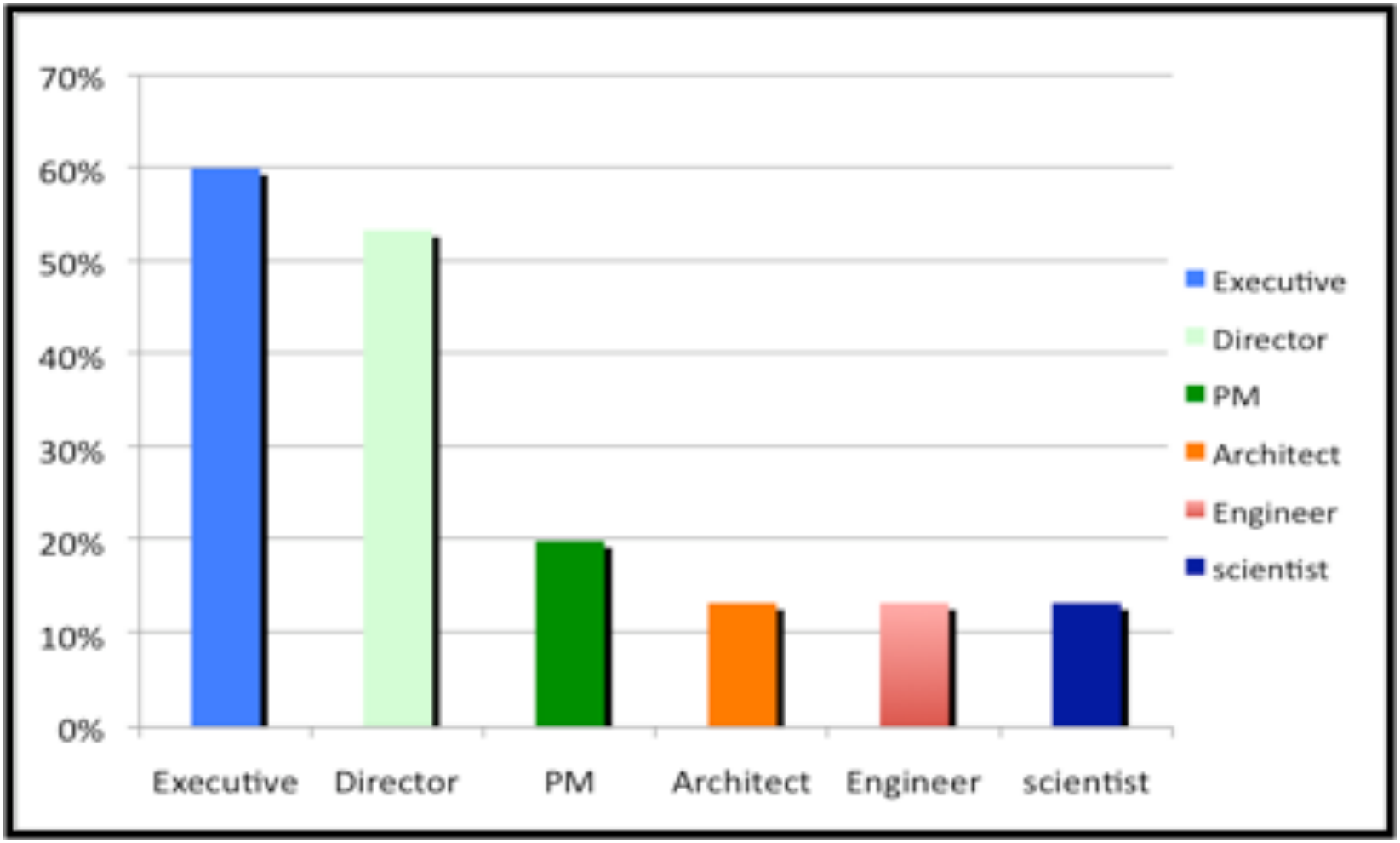


Kirkpatrick Level 4 – ROI

- None of the executive sponsors measured true ROI.
- All ROI discussions were qualitative – all felt the program was very worthwhile.

How was SCF Principle Implemented?

Individuals from industry with background that would appeal to sponsors targeted to be SCF. Many SSEP faculty are SCF. Last 3 positions:



SCF Contributions and Reasons to Join

Contributing to defining and executing some of SSEP strategies.	80%
Developing courses and/or programs	80%
Recruiting industry or government partners for Stevens' SE program.	73%
Contributing to attracting research funding for Stevens' SE program	53%
Being active in research publications	47%
Advising and attracting PhD professional students to the program.	33%
Providing quality education that keeps the customers satisfied	27%
Establishing, guiding and participating in governance structures at both school and institute levels	7%
Assisting in marketing efforts	7%
Leading quality SSE online teaching program	7%
Directing the SERC	7%

Reasons to join Stevens	Response rate
The flexibility to work remotely	47%
Teaching professional students	47%
Opportunity to assume leadership roles	33%
Opportunity to use personal experience to teach	33%
Opportunity to conduct applied Research	27%
To be part of a growing organization with entrepreneurial spirit.	20%
Respectful and respected colleagues	7%
Attractive compensation and benefits	7%
Opportunities for travel	7%
Intellectual freedom and research	7%
Build the department of SE and Eng. Management	7%
Returning to Academia	7%

Summary

- In last decade, # of SCSE master's graduates growing rapidly with newer programs experiencing most of the growth
- In last decade, # of SCSE PhD graduates modest and not growing
- NTTF used less often in SE programs than authors anticipated
- SSEP OAM implementation correlates positively with the growth of the educational enterprise, less so with more immature research enterprise
- Approach to analyzing SSEP impact could be tried at other universities offering SCSE graduate programs