GEOHORIZONS

A comparison of the geoscientific, nontechnical, and soft skills needed by service-industry geoscientists with those required by oil-company geoscientists

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ABSTRACT

Service companies now offer an increasing range of services to oil companies in response to significant restructuring of the petroleum industry, creating gaps in their in-house technology. A total of 58 service companies from 10 business sectors completed a survey covering 150 geoscientific, computer, nontechnical, soft, and other skills. Using their data, the author compared the skills needed by geoscientists employed in the service industry with those required in oil companies.

Excepting companies in reservoir characterization, geology, geophysics, and remote sensing, service-company geoscientists need fewer geoscientific skills but greater computer competency than do oil-company geoscientists. The key subdisciplines are sedimentology, petroleum geology, stratigraphy, subsurface mapping techniques, introductory structural geology, introductory geophysics, and log/core analysis. However, each business sector has unique requirements reflecting their principal business focus. Many require a mix of geoscience with another discipline such as engineering for well-logging firms. These variations produced different skill rankings in each segment of the service industry. The key nontechnical and soft skills are critical thinking, ethics, and commitment. Service companies also place greater emphasis on written, oral, and listening communication skills than do oil firms.

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Service companies also require math skills superior to oil-company needs together with good marketing and project management business capabilities. To aid geoscience students, prevailing recruiting trends are reviewed, and the need for work experience is stressed. Like oil companies, only large service companies recruit inexperienced graduates. Applicants may be expected to have advanced degrees.

Geoscience departments must address the needs of service companies when contemplating degree and curricula reform. Course relevance is essential as is education in professional ethics.

INTRODUCTION AND BACKGROUND

Between 2001 and 2002, 62 oil companies and 58 service companies completed an industrywide survey distributed by the author to identify and evaluate the skills that the petroleum industry now expect their geoscientists to possess. Heath (2003) described the needs and expectations of the oil companies, together with details on the survey's background, definitions, methodology, and the scoring system. This article compares the needs of the service industry with those of the oil companies. Service companies comprise a significant segment of the petroleum industry and provide general and specialist skills to oil companies. The range of services offered has increased because oil companies either restructured or outsourced noncore activities. Service companies, like oil companies, have changed radically over recent decades and largely for the same reasons: changing technology, corporate restructuring, and the emergence of a global economy.

OBJECTIVES AND METHODOLOGY

These industrywide changes will affect those students wanting petroleum industry careers because they will have to develop some new skills not necessarily taught in geoscience departments. Geoscience departments, however, may be reluctant to change existing programs unless they have a clear understanding of why reform is necessary and which topics are now important to the industry. Therefore, the principal objective of this study (and Heath's 2003 oil company survey) is to provide students and geoscience departments alike with the necessary data by determining exactly what skills service-company employers now require. These skills comprise numerous subdisciplines of geoscience, computer technology, and several other topics grouped here under the heading of ''Nontechnical and Soft Skills,'' whose characteristics are described in Heath's 2003 article. Although some skills are learned, others appear to be innate, being part of an individual's psychological makeup.

For geoscience graduates, finding a job is a key component of embarking on a career. As part of their restructuring and to improve overall efficiency, many companies have developed more sophisticated recruiting techniques and strategies. Unless students and geoscience departments are aware of these, there's a risk that service companies will neither employ faculty as consultants nor hire their graduates.

Data Collection and Scoring

Questionnaires distributed to the petroleum industry contained about 110 preferential ranking exercises and some open-ended questions. Most responding service companies were American or Canadian controlled. However, 12 were owned by European companies, and 1 was owned by Australian interests. This ownership mix, not found among the North American oil companies surveyed, may reflect the global nature of the modern service industry. Like most people in service companies, the majority of respondents had worked for oil companies earlier in their careers. They possessed a wide range of educational backgrounds. Many had M.B.A. degrees. About 80% were geoscientists, predominantly geologists. Two thirds of the respondents were middle or senior executives, whereas the rest were practicing scientists. On average, they had about 21 yr of work experience. Only two service companies employed more than 80,000 people and were therefore comparable in size to giant oil companies. Both were fully integrated corporations possessing the very wide range of expertise necessary to manage large-scale projects. Information provided by participants revealed that only 5 other service companies employed more than 1000 people vs. 20 oil companies. Of the remainder, most were small niche players offering specialized or limited services, such as geochemistry or terrain analysis.

The survey data were sorted according to the respondents' assessments of their core businesses. This produced 10 groups or business sectors within the service industry (Table 1) and enabled the investigator to determine the unique needs and requirements of each. Although the number of participants in each group varied, the survey results are fairly representative of both the business sectors and the service industry as a whole.

Table 1. Composition of Skill Profile by Business Sector*

Number of Respondents	Business Sector	Geosciences	Computer Skills	Nontechnical and Soft Skills
62	Oil company average	58	18	24
3	Reservoir characterization	57	20	23
13	Geological consultants	52	27	21
9	Geophysical contractors	44	30	26
5	Potential fields (magnetics, gravity)	44	32	24
4	Petrology and petrography	67	14	19
4	Geochemistry	44	19	37
5	Well logging	34	24	42
4	Remote sensing	42	29	29
6	Software	37	34	29
5	Data and information service	39	37	24
	Service industry average	**46**	**27**	**27**

*Expressed in percentages.

The assessments in each business sector were converted into scores using the process outlined in Table 2 and described in detail by Heath (2003). In the tables accompanying this article, subdisciplines or skills have been listed in descending order of the average scores calculated for the North American oil companies (Heath, 2003). This approach provided a consistent baseline that facilitated service business sector and oil-company comparisons. To save space, several lower scoring topics evaluated by both oil and service companies have been omitted. However, marketing and sales skills were added to the business education section because these were thought to be important in the service industry. In addition, to reduce number clutter, only scores exceeding 50 have been presented. By implication, the blank spaces highlight topics that are of limited importance to employers.

The layouts of Tables 3–9, 11 show reservoir characterization (field development), geological consultants (petroleum geology), and geophysical contractors (petroleum geophysics) to the left. All three business sectors provide expertise that is closely linked to the key activities of oil companies: exploration, development, and production. Scores for companies involved in acquisition of potential field data (magnetics and gravity) are placed next to geophysical contractors because the two are related.

Business sectors that are less directly linked with these principal oil company activities, such as software and data and information companies, have been placed to the right. Below each business sector heading, the scores for each topic are listed. The average score at the bottom includes the sub-51 scores represented by blanks. The right-hand column of these tables has

Table 2. Calculation of Scores Used for Ranking Topics

Step 1. How 13 geological consultants voted on the level of competency required in reflection and refraction seismic geophysics

Very high	High	Reasonable	Limited	Low or not required
1	2	7	3	0

Step 2. By applying a modification of Likert's (2005) technique, each "Very high" vote was assigned a value of 4 points, with "High," "Reasonable," "Limited," or "Low" scoring 3, 2, 1, and 0, respectively, so that

Very high	High	Reasonable	Limited	Low or not required	Sum of scores
$1 \times 4 = 4$	$2 \times 3 = 6$	$7 \times 2 = 14$	$3 \times 1 = 3$	$0 \times 0 = 0$	27

Step 3. The maximum score possible was 13×4 or 52. Therefore, 27 may be expressed as a percentage of 52; thus, $(27/52) \times 100 = 51.9\%$. This is rounded up to 52 to produce the "Score" used in the tables.

Table 3. Geoscience Skills: Top 20 Geoscientific Skills

Oil Company Average Score	Subdiscipline	G = Geophysics; M = Multidisciplinary	Reservoir Characterization	Geological Consultants	Geophysical Contractors	Potential Fields
87	Sedimentology or sedimentary geology		83	75	61	64
87	Stratigraphy		75	85	58	71
84	Petroleum geology		67	81	58	68
82	Geophysical interpretation and mapping	G	58	79	89	75
82	Subsurface mapping techniques	M	67	79	56	54
80	Introductory geophysics	G	67	77	89	79
76	Introductory structural geology		67	75	61	75
76	Log/core analysis	M	67	60		
76	Sequence stratigraphy	M	67	69	58	
74	Play assessment	M	67	83	53	
71	Reservoir geology			67		
68	2- and 3-D modeling (seismic mapping)	G	58	71	61	
68	Basin analysis	M	75	81		
63	Reflection and refraction seismic	G		52	75	57
61	Advanced structural geology		58	58		54
60	Regional geology		58	75	64	61
59	Sedimentary structures		83		69	82
59	Operations geology					
58	Petroleum economics			60		
57	Special rock studies		75	56		
71	**Business sector average**		**63**	**68**	**58**	**57**

*Tie in ranking.

two subdivisions. One contains the service-industry topic average score, again including the blanks. The adjacent column ranks the key topics for the service industry.

THE SKILL PROFILE

As in earlier work (Heath, 2000a, b; 2002a, b; 2003), the skill profile comprises three sets of skills considered essential to petroleum-industry geoscientists: geological and geophysical knowledge, competency in computer science, and possession of the previously defined nontechnical and soft skills. Table 1 shows skill profile compositions for each business sector expressed in percentages. The oil-company profile is shown at the top of the table, and that of the service industry is shown at the bottom. Comparing the two profiles shows that the service-industry average of 46% for geoscience is well below the oil-company figure of 58%. Only petrography, reservoir characterization firms, and geological consultants have geoscientific skills exceeding 50% of the profile. This is offset by the 27% assigned to computer skills, which is much higher than the oil-company figure of 18%. The nontechnical and soft skill percentages in both profiles are broadly similar as are most business sector averages. However, geochemistry and well-logging company percentages seem unusually high.

Petrography and Petrology	Geochemistry	Well Logging	Remote Sensing	Software	Data and Information Services	Service Industry	
						Average	Rank*
88		60		54	55	63	2
81		55		54	65	62	3
81	56	70	67	71	55	68	1
			67			51	12=
			75	75	55	57	6
			67			58	5
63			92		55	60	4
88		80		63		56	7=
			58			48	15=
						48	15=
63			58	75		51	12=
			67			45	19=
	56		67			53	11
			58			37	
56			92			50	14
69			58			54	10
81				64		55	9
75						35	
						34	
63						42	
57	**29**	**43**	**54**	**41**	**40**	**51**	

Geological and Geophysical Skills

Table 1 shows geoscience to be the key component of the service industry's skill profile. Table 3 ranks the 20 most important of the subdisciplines according to oil-company data (Heath, 2003), whereas Table 4 ranks 20 of lesser significance. In many cases, the scores are higher than oil-company numbers. Reservoir characterization firms, geological consultants, remote sensing firms, geophysical contractors, and potential field firms require the widest range of subdiscipline skills, averaging 20 each. Most appear in the middle and upper part of Table 3. Clearly, these sectors consider geoscientific knowledge to be important in their business. The remaining business sectors require fewer geoscientific skills, and the scores are lower. It is probable that disciplines not covered by this survey are more important to these business sectors than is geoscience. Likely examples include engineering for logging companies and computer science (Tables 1, 5, 6) and math (see below) for software firms. Geophysical contractors demand much greater capability in geophysics topics than do oil companies because this capability is their marketable asset.

The specialist nature of their core businesses means that few service companies consider multidisciplinary geoscientific skills to be important. The main exceptions are geological consultants (play assessment and basin analysis) and reservoir characterization firms (basin analysis). Most service companies gave high scores for topics in their field of expertise. It is the combination of these skills and disciplines that service

Table 4. Geoscience Skills: Bottom 20 Geoscientific Skills

Oil Company Average Score	Subdiscipline	G = Geophysics; M = Multidisciplinary	Reservoir Characterization	Geological Consultants	Geophysical Contractors	Potential Fields
55	Applied and operations geophysics	G	58		83	71
55	Rock-fluid interaction			56		
51	Field and mapping skills		67			54
50	Inversion geophysics	G			61	61
48	Organic geochemistry					
46	Global geology		58	60	58	64
45	Petrology and petrography		75			
44	Plate tectonics and geodynamics			60	53	57
44	Potential fields (gravity and magnetics)	G			75	61
43	General geochemistry		58			
43	Biostratigraphy					
42	Time-series analysis	G				
38	General paleontology					
35	Micropaleontology (forams, ostracods, etc.)		58			
35	Geomorphology					
29	Recent, Quaternary, or surficial geology		67			57
29	Terrain analysis (R.S. data, air photo)	M				
27	Marine geology or geological oceanography					
23	Palynology					
20	Coal geology					
42	**Business sector average**		**51**	**39**	**40**	**44**

*Tie in ranking.

companies provide oil companies who may no longer have such skills in-house. Examples include remote sensing firms (advanced structural geology and terrain analysis), well-logging companies (log/core analytical skills and engineering), and geophysical contractors who provide expertise in both geophysics and math (see below). The lack of space meant that topic rankings in each business sector could not be included in the tables. Aside from geophysical interpretation and mapping, the top-ranked service industry skills are similar to those valued by oil companies: sedimentology, petroleum geology, stratigraphy, subsurface mapping techniques, introductory geophysics, introductory structural geology, and log/core analysis. However, opinions diverge thereafter. It came as a surprise to find that knowledge of global geology, which received a high score of 56, ranking it seventh, equal with log/core analysis. This might reflect the more international composition of service-company respondents vs. the restricted vision of oil companies operating in America.

Computer Competency

Table 1 shows the service industry placing much greater emphasis on computer competency than do oil companies: 27% vs. 18%, respectively. However, this is somewhat misleading because the particularly high percentages reported by data and information services

Petrography and Petrology	Geochemistry	Well Logging	Remote Sensing	Software	Data and Information Services	Service Industry	
						Average	Rank*
			58			46	17=
						43	
56			58			44	
						34	
	56					38	
	88		58		60	56	7=
63			58			45	19=
63			67			46	17=
			83			37	
	69					37	
						24	
						28	
						26	
						19	
			75			34	
63						34	
			92			35	
			67			34	
						15	
						24	
36	**22**	**31**	**43**	**20**	**24**	**35**	

(37%), software (34%), and potential field companies (32%) have been offset by the low percentages of 14, 19, and 20% calculated for petrography, geochemistry, and reservoir characterization firms, respectively.

This dichotomy is apparent on Table 5, ''General Operations.'' Here, topic scores exceeding 50 are relatively common throughout the table, but mainly in its upper half. Many scores exceed oil-company figures by considerable margins. Consequently, the business sector averages for geological consultants, software firms, data services, and remote sensing are much higher than oil-company averages. It is surmised that this superior computer competency is another service these business sectors provide oil companies. Elsewhere, data and information service companies value database skills, whereas software companies consider programming skills important. The lack of interest in computer technology by both petrography and geochemistry business sectors is clearly evident. Their data, together with well-logging company scores, have reduced the service industry topic averages significantly.

Table 6 evaluates geoscience-specific computer skills associated with exploration and field operations. Although individual topic scores may be higher than oil-company scores, only exposure to workstation interpretation systems is considered relatively important throughout the service industry. The high topic scores and elevated business sector averages calculated for reservoir characterization firms, geological consultants, and geophysical contractors suggest that these

Table 5. Computer Skills: General Operations

Oil Company Average Score		Subdiscipline	Reservoir Characterization	Geological Consultants	Geophysical Contractors	Potential Fields
68	Exposure to	Personal Computers (PCs)		75	72	64
56		UNIX			53	54
45		Peripheral equipment		58		64
58	Graphics	Presentation (e.g., PowerPoint)	75	73	67	
33		Advanced (e.g., Corel Draw)	67	54		
55	Internet	Searching (e.g., Accessing)		69	63	57
40		Application (e.g., FTP, Telnet)				
45	GIS	Simple (e.g., ArcView)		60	53	
34		Advanced (e.g., ArcInfo)				
37	Database	Simple (e.g., FoxPro)		85		
32		Advanced (e.g., Oracle)				
22		Design and management				
18	Programming	Introductory (e.g., C++, Fortran)				
14		Advanced (e.g., C++, etc.)				
40	**Business sector average**		**34**	**53**	**41**	**40**

*Tie in ranking.

Table 6. Computer Skills: Geoscience-Specific Operations

Oil Company Average Score	Subdiscipline	G = Geophysics; M = Multidisciplinary	Reservoir Characterization	Geological Consultants	Geophysical Contractors	Potential Fields
63	Workstation interpretation systems (ProMax, Datamine, etc.)		75	63	72	61
52	Geophysical modeling (seismic and potential fields)				75	75
50	Geophysical processing (Geosoft, ER Mapper, etc.)		58		72	57
49	Geological modeling PC-Xplor, RockWare)		75			
47	Statistical data (SAS, etc.)			62		
37	Exploration and mapping packages (Vulcan, DataMine, MicroMine, etc.)		52			
27	Geochemical-spatial (e.g., Arc View, etc.)		63	56		
24	Remote sensing (Terrasat, ER Mapper, etc.)					
44	**Business sector average**		**58**	**50**	**51**	**45**

*Tie in ranking.

Petrography and Petrology	Geochemistry	Well Logging	Remote Sensing	Software	Data and Information Services	Service Industry	
						Average	Rank*
		70	69	90	65	59	2
				70	60	43	7=
		55		70		48	5
			69	67		60	1
					56	49	4
	67		63		70	56	3
			56			43	7=
			81			41	
			75			32	
					56	42	9=
					56	30	
						23	
				65		30	
				65		29	
22	**31**	**27**	**45**	**52**	**47**	**42**	

Petrography and Petrology	Geochemistry	Well Logging	Remote Sensing	Software	Data and Information Services	Service Industry	
						Average	Rank*
				58		46	6
						37	
						35	
				67		40	
	56					42	9=
				58		36	
						33	
			81			32	
12	**19**	**27**	**46**	**39**	**32**	**35**	

Table 7. Nontechnical and Soft Skills: Top 20 According to Oil Companies

Oil Company Average Score	General Operations	Reservoir Characterization	Geological Consultants	Geophysical Contractors	Potential Fields
91	Critical thinking	100	100	88	87
91	Ethics and integrity	92	88	89	90
91	Willingness to learn	92	87	89	65
88	Dependability and reliability	83	65	89	80
88	Commitment	83	90	89	80
88	Initiative	83	85	92	80
87	Desire to achieve and motivation	83	87	83	80
86	Oral communication	83	92	86	85
86	Teamwork	92	81	75	80
86	Drive, energy, enthusiasm	83	85	86	80
86	Creativity and out-of-the-box thinking	83	85	89	60
85	Cooperation	83	83	78	75
85	Problem solving	83	77	89	60
84	Adaptability and flexibility	83	96	81	75
81	Can cope with stress and pressure	75	75	81	75
81	Self-management and take responsibility	83	85	81	75
81	Analytical skills	83	85	72	75
81	Can summarize and abstract	75	54	75	80
80	Listening	83	71	86	70
79	Spatial thinking and 3-D visualization	83	73	81	55
85	**Business sector average**	**84**	**82**	**86**	**75**

*Tie in ranking.

sectors can obtain contracts to work on proprietary exploration and operational projects.

Combining the data presented in the two tables suggests that oil companies place greater emphasis on geoscientific-specific computer operations, whereas service companies seem to stress general computer operations, particularly presentations, personal computer work skills, internet search, and advanced graphics.

Nontechnical and Soft Skills

The skill profiles presented in Table 1 show that both oil companies and the service industry companies place considerable emphasis on the possession of good nontechnical and soft skills, particularly well-logging and geochemical companies. This observation is supported by the remarkably high scores computed for most of the 37 attributes evaluated in Tables 7 and 8. Table 7 lists the 20 attributes most favored by oil companies and contains most of the high-scoring attributes identified by the service industry. This might reflect a shared value system. With the exceptions of potential field firms and data service companies, most of these scores are close to oil-company figures as are most business sector averages. The high scores given for written communication (86), oral communication (83), and listening (82) suggest that service companies place considerable emphasis on the need for good

Petrography and Petrology	Geochemistry	Well Logging	Remote Sensing	Software	Data and Information Services	Service Industry	
						Average	Rank*
87	87	88	No data	100	75	93	1
100	94	90	69	79	85	88	2=
94	90	95	81	96	80	87	5
100	94	85	88	96	70	85	8
81	94	100	94	90	80	88	2=
94	83	90	81	75	80	84	9=
75	81	85	81	88	90	83	11=
100	94	85	88	92	75	88	2=
81	94	85	81	92	80	84	9=
81	81	85	81	83	85	83	11=
81	81	85	75	75	70	78	
88	100	75	88	90	85	86	6=
88	81	85	75	83	80	80	17=
75	88	85	75	70	75	80	17=
94	90	85	81	83	70	81	14=
94	94	80	81	71	70	81	14=
94	88	75	69	95	75	80	17=
88	81	65	56	90	65	73	
81	88	85	94	83	80	82	13
56	56		63	63	65	64	
86	**86**	**82**	**79**	**85**	**77**	**82**	

communication skills in their businesses. However, most service-industry scores were lower than oil-company figures, particularly for spatial thinking (64 vs. 79) and, to a lesser degree, leadership, creativity, and summarizing, all of which lag oil-company figures by eight points.

Some unusually low scores in the 1950s and 1960s are scattered throughout the table. For instance, geological consultants give dependability a score of 65, ranking it 28th, whereas oil companies placed it in third position, with a score of 88. Other examples include potential field (creativity = 60) and software companies (adaptability = 70). What accounts for these anomalously low scores, especially for spatial thinking, is unknown.

Table 8 evaluates 17 attributes considered less useful by oil companies. It appears that service companies place greater value on written communication skills, independence, and time management than do oil companies, although scores in individual business sectors vary considerably. The service-industry scores for risk taking (52) and entrepreneurial flair (56) are much lower than oil-company figures (64 and 63, respectively), which, as was the case for oil companies, place them near the bottom of the table. Perhaps these low scores, combined with the relatively low score for creativity in Table 7, reflect the primary function of service companies: that of gathering and processing data for clients instead of fostering innovation.

Table 8. Nontechnical and Soft Skills: Bottom 17 According to Oil Companies

Oil Company Average Score	General Operations	Reservoir Characterization	Geological Consultants	Geophysical Contractors	Potential Fields
78	Written communication	75	90	78	85
78	Time management	83	85	81	75
78	Self-confidence	69	75	75	70
78	Logical argument and reasoning	92	79	78	65
78	Can overcome adversity	75	74	65	65
77	Independence and self-reliance	83	83	61	67
77	Task oriented	88	67	80	75
73	Inquiry and research skills	75	77	78	70
71	Rapid conceptualization of ideas	69	75	69	65
69	Leadership	58	67	67	
65	Intellectual ability (e.g., good grades)	75	69	64	60
64	Risk taker		62		55
63	Entrepreneurial flair	58	63	58	55
60	Cultural flexibility and awareness	75	64	64	80
54	Numeracy (2 yr university math)	75	65	69	
46	International living and travel	67			
40	Nonnative language skills		56		55
68	**Business sector average**	**69**	**70**	**63**	**64**

*Tie in ranking.

Table 9. Math and Business Education

Oil Company Average Score		Reservoir Characterization	Geological Consultants	Geophysical Contractors	Potential Fields
	Math Education				
49	Applied math	75	52	78	
49	1 yr of geostatistics	58			
49	1 yr of calculus			72	
45	Classical statistics	58		53	
38	2 yr of calculus	58		78	
23	$\geq$2 yr of geostatistics			53	
42	**Business sector average**	**55**	**43**	**64**	**37**
	Business Education				
60	General awareness only		58		
54	Project management	58	62	67	55
54	Economic analysis		63		
46	Planning and strategy		58	56	
44	Some business courses		52		
41	Finance and budgeting				
28	Marketing and sales			70	
49	**Business sector average**	**46**	**55**	**48**	**39**

*Tie in ranking.

Petrography and Petrology	Geochemistry	Well Logging	Remote Sensing	Software	Data and Information Services	Service Industry	
						Average	Rank*
88	100	85	88	83	85	86	6=
94	88	65	75	88	70	80	17=
88	80	80	75	67	60	74	
75	69	75	69	75	65	74	
94	80	80	63	70	70	74	
92	94	90	81	75	80	81	14=
75	75	75		83	67	74	
63	75		69	75	70	70	
69	69	65	69	71	70	69	
56	69	70	63		60	61	
63		55	56	63	70	63	
69	56	55			55	52	
56		60	69			56	
	81	58	88	75		67	
	69			67		58	
						40	
			56			40	
65	**68**	**65**	**65**	**63**	**62**	**65**	

Petrography and Petrology	Geochemistry	Well Logging	Remote Sensing	Software	Data and Information Services	Service Industry	
						Average	Rank*
		58		63		53	1
				58		40	3=
						40	3=
	63			58		46	2
						38	5
						30	6
31	**28**	**36**	**40**	**52**	**26**	**41**	
						44	3
75	75		63			57	1
						37	6
	56					40	4=
						40	4=
						34	7
					75	51	2
36	**54**	**31**	**37**	**35**	**48**	**43**	

Table 10. Other Math Skills Evaluated by 15 Service Companies

Math Topic	Oil Company Average	15 Company Average
Linear algebra	44	58
Matrix algebra	38	42
Partial differentiation	31	37
Multivariate calculus	27	30
Average scores	**35**	**42**

Like the North American oil company results, service-industry scores for the global skills of nonnative languages, international travel, and cultural awareness are generally low. Nonnative language skills were ranked 37th and last by both groups. Clearly, nobody in the petroleum industry recognizes the importance of knowing the local language when operating overseas. Scores for international living and travel experience were also low in both groups. Service companies seem to understand the advantage of possessing good cultural flexibility and awareness skills (67), whereas oil companies apparently do not. However, among the larger service and oil companies, the principal recruiters of young graduates, scores for most global skills were higher.

Apart from the aforementioned written communications (ranked 6th by the service industry), independence (14th) and time management (17th), the composition of the top 20 ranked attributes cited by the service industry and the oil companies is similar, although the ordering of the skills is different and the service industry scores are generally lower.

OTHER SKILLS: MATH AND BUSINESS EDUCATION

Although competency in the key components of the skill profile is essential, other abilities are also important today. These include knowledge of math, and an understanding of prevailing business practices.

Math Education

Advances made by oil and service companies in the application of computer science and statistics have been driven by breakthroughs made in electronics and math. If geoscientists are to use these new technologies effectively, they must have a reasonable understanding of the mathematical principles that form their underpinnings. Unpublished data collected by Heath in the 1996–1997 Canadian survey showed that government geoscience agencies, mining firms, and oil companies preferred their geologists to have 2 yr of university math education, whereas their geophysicists required closer to 3 yr. These findings were supported by the relatively high math education scores obtained in subsequent oil-company studies (Heath, 2000b; 2002a, b; 2003).

North American oil company respondents evaluated 10 math subdisciplines (Heath, 2003), but the service industry reviewed only 6 (Table 9). Skills in applied math, classical statistics, geostatistics, and calculus are most in demand in the geophysical contractor, reservoir characterization, and software business sectors. Their high scores raised their business sector averages well above oil-company figures. The remaining business sectors have very limited interest in math skills.

Inadvertently, 15 service companies from various business sectors did evaluate the 4 math topics not presented in Table 9. The data showed geophysical company scores to be very high: particularly for linear and matrix algebra (both 88). Had these scores been incorporated into Table 9, the service industry averages of 58 for linear algebra and 42 for matrix algebra would rank them first and third, respectively.

Business Education

Ward (2000, 2001) suggested that many British trained geology graduates reduced their chance of employment through their lack of business skills. Heath (2000a, 2002a) found that North American geoscience-based companies wanted some business education added to the geoscience curricula. In these and subsequent studies (Heath, 2000b, 2002b, 2003), companies were asked to evaluate six topics that might be included. Table 9 presents service company results. Many topic scores were higher than oil-company figures, particularly in the geological consultant and geochemistry business sectors. However, well-logging, software, and petrology firms showed limited interest. Most service companies considered project management and marketing and sales skills to be more important than the less explicit general awareness of business favored by oil companies. Marketing skills and project management

go hand in hand. It takes good marketing techniques by service companies to win contracts and competent project management skills to process them.

SOME ASPECTS OF THE RECRUITING PROCESS

Having acquired a mix of the critical skills outlined in this article, students have one more obstacle to negotiate: that of getting a job. Heath's unpublished 1996–1997 data revealed that most Canadian-based companies either contacted faculty members when seeking recruits or waited for graduates to take the initiative. The use of co-op programs and internships as recruit evaluation tools was not widespread at the time and therefore was not evaluated. However, today, these techniques are widely used and add considerable rigor to the recruiting process. They allow employers to evaluate many technical components of the skill profile discussed here and to assess how candidates might fit into the corporate workforce, which is where many soft skills come into play. However, this has not eliminated the need for campus visits by larger companies. As in previous surveys (Heath 2000a, b; 2002a, b; 2003), service companies were asked to explore some recruit-related issues: selecting which departments to visit, geoscience curricula, degree requirements, and the value of field and mapping training programs and prehiring work experience.

Heath (2003) found that North American oil companies with fewer than 250 employees very seldom recruit inexperienced geoscientists. Only 11 service companies had more than 250 staff whereas 33 employed fewer than 50. Many confirmed that they recruited only experienced staff and were therefore less likely to visit universities. Consequently, the service company comments may be less relevant than oil company input.

University and Other Reputations

Table 11 reviews four possible criteria that might be used when selecting which geoscience departments to visit. Apart from a few high scores widely scattered throughout the table, topic scores are below oil-company figures. Exceptions include the 75 scored by reservoir characterization firms for curriculum and 75 by data services for university reputations. Overall, curricula and department reputations seem more important than reputations of universities or supervisors. Data from the 11 larger service companies produced higher topic average scores but still slightly below oil-company figures, perhaps reflecting closer contacts with departments compared to the smaller service companies.

Geoscience Curricula and Minimum Degree Requirements

Data on Table 11 show that, apart from geological consultants, service companies are less enthused about having multidisciplined geoscientists than are oil companies. This may be a consequence of the more specialized nature of service companies as previously suggested.

In the oil-company survey (Heath, 2003) 83% of American companies claimed that, for both geologists and geophysicists, a master's degree was already the minimum requirement for employment or was becoming so. However, most Canadian firms still considered a bachelor's degree to be sufficient. Service companies reported that almost 20% wanted their geology recruits to have a master's degree, and a further 29% believed that this requirement was becoming the norm. Only 12% of the respondents expected their geophysicists to have graduate degrees, but another 30% thought that this represented a trend. However, the master's degree requirement was well established among the seven largest service companies. Combining oil- and service-company data suggests that the master's degree requirement is becoming more commonplace throughout the petroleum industry.

The Role of Field Skills and Mapping in Recruiting

Field and mapping skills were once considered essential components of geoscience education. However, in the 2003 study, the average score for this topic was only 51, which reflected the limited interest of most oil companies. The service-industry score was even lower at 44. When asked how many days of field and mapping training or experience would be sufficient, reactions of service companies varied. Some, such as remote sensing and well-logging firms, favored extensive training (85 and 75 days, respectively). Others, such as geophysical contractors and software companies, preferred about 40 days. The service industry average was 53 days—5 days less than the oil-company figure.

Prehiring Work Experience

The role that prehiring work experience played in recruit evaluation was also investigated. Table 11 shows that overall, most scores and averages are below oil-company data, sometimes by significant margins. Like

Table 11. Factors that Might Influence the Recruiting Process: University Selection, Discipline Mix, and Prehiring Work Experience

Oil Company Average Score		Reservoir Characterization	Geological Consultants	Geophysical Contractors	Potential Fields
	Department Selection				
67	Curriculum	75	60	44	38
64	University's reputation	63	35	44	38
61	Department's reputation	58	63	47	38
47	Thesis supervisor's reputation	67	56	50	26
60	**Business sector average**	**66**	**54**	**46**	**35**
	Need for Knowledge of both Geology and Geophysics				
	Essential		10	4	1
	Very important	3	2	2	2
	Useful			2	
	Somewhat useful		1		
	Not important				
	No data			1	2
81	**Business sector average**	**75**	**90**	**81**	**83**
	Prehiring Work Experience				
79	Industry-related work experience	83	81	75	60
58	Present or past responsibilities (leadership)	50	54	53	30
39	Government or university research	67	46	41	30
38	Volunteer work	38	29	31	25
28	Nonindustry-related work (e.g., waiter)	25	44	28	35
48	**Business sector average**	**53**	**51**	**46**	**36**

*Tie in ranking.

oil companies, service companies place great emphasis on industry-related work experience although less on leadership. This could reflect their preference for recruiting working scientists instead of potential managers. Only reservoir characterization firms valued research experience. Like most oil companies, service companies were not overly impressed by volunteer and other nonindustry-related work experience.

OBSERVATIONS AND CURRICULUM REFORM

The topic scores and rankings presented in this study should help students develop course-taking strategies aimed at establishing careers in either the oil or service segment of the petroleum industry. Alternatively, students may focus on developing skills in the high-scoring topics favored by a specific service business sector. In either case, they will be frustrated unless geoscience departments modernize both their curricula and degree programs and make courses more relevant. The recommendations outlined below are similar to those cited in the oil-company study (Heath, 2003) but with refinements aimed at meeting the special needs of service companies.

1. The key geoscience topics required by both the service industry and oil companies are broadly similar. However, having a mix of multidisciplinary skills is less important in the service industry where many companies require specialist skills instead. Examples include the need by remote sensing companies for skills in terrain analysis, geomorphology, and potential fields whereas geophysical contractors and potential field companies prefer geoscientists with knowledge of applied and operations geophysics. To

Petrography and Petrology	Geochemistry	Well Logging	Remote Sensing	Software	Data and Information Services	Service Industry	
						Average	Rank*
38	44	45	63	25	55	49	2
31	31	50	44	42	75	45	3
38	44	45	63	54	55	51	1
25	44	30	31	21	45	39	4
33	**41**	**43**	**50**	**36**	**58**	**46**	
	2	1		1	1		
1	1		1	1	2		
	1	3	2	2	2		
1	1						
2			1	2			
50	**70**	**63**	**58**	**69**	**40**	**71**	
75	75	70	69	71	60	72	1
31	63	75	56	33	15	46	2
17	38	40	44	30	20	37	3
17	13	40	38	20	30	28	4=
13	6	45	38	25	20	28	4=
31	**49**	**54**	**51**	**36**	**29**	**44**	

accommodate these and other new courses, geoscience departments should reduce emphasis on some low-scoring subdisciplines such as paleontology and surficial geology.

2. Some service companies offer expertise comprising a mix of geoscientific knowledge and another discipline that clients commonly lack. The example of well logging, which requires both geoscientific and engineering knowledge, has been cited elsewhere, but other cases exist. Such mixes could be accommodated by geoscience departments through development of new initiatives such as increased interfaculty curricula and degree programs.
3. Geoscience departments need to ensure that computer science education meets the requirements of service companies, particularly in the area of general operations. This may require additional math education in linear algebra, applied math, and matrix algebra besides geostatistics or calculus. The acquisition of superior math and programming skills will greatly enhance a student's employment opportunities.
4. Possession of good nontechnical and soft skills is vital for all service-company geoscientists. Therefore, it is essential that departments stress this to students. Any discussion about soft skills must include professional ethics. A 2004 telephone survey of 31 North American geoscience departments revealed that only one addressed the issue in any detail. Service companies also require superior skills in oral and written communications and listening, critical skills when working with clients.
5. Some business education should be included in geoscience curricula. A general awareness of business issues and knowledge of project management skills are important to oil and service companies alike.

However, whereas oil companies value exposure to economic analysis, service companies think marketing skills are more important.

6. To meet the needs of the global economy, departments should expand international exchanges to provide students with international experience and exposure to other cultures. Learning nonnative languages should be encouraged.

CONCLUSIONS

This study shows the range of skills that service business sectors require in order to provide their services to oil companies. Generally, multidisciplinary geoscience skills are less important because service companies commonly provide a mix of specialist or interdisciplinary skills. For service companies, general operations computer skills are more important than geoscience-specific skills. Both service and oil companies value nontechnical and soft skills, although the former considers good communication skills to be essential for working with clients. Many service companies also value superior math knowledge and good marketing and project management capabilities. Only large service companies are likely to recruit inexperienced graduates, and a graduate degree may become the minimum qualification for employment. It will take considerable innovation by geoscience departments to accommodate the changing needs of both geoscience students and service industry employers.

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