Technical and Non-technical Skills Needed by Oil Companies

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ABSTRACT

Political, economic, and social changes have forced oil companies to redesign their corporate goals and business strategies in order to survive. They have restructured themselves and refocused on core businesses, and employees not having the skills needed in this new economy have been laid off. The aim of this paper is to identify the new skills that are required today so that geoscience students can prepare more effectively for careers in the oil industry and to help geoscience departments upgrade their curricula. The findings should help employers and departments to better understand each other's needs and improve cooperation between them, thereby benefitting the geoscience community as a whole.

The data presented were gathered from 29 oil companies based in Britain, the most international petroleum community outside the United States. The firms surveyed employ more than 382,000 people, including over 6,000 geoscientists. Representatives from each company completed a 150-item questionnaire comprised of a mix of preferential ranking, box-filling exercises, open-ended questions, and observations designed to assess the importance of a wide range of skills and other issues. More than 40 geological and geophysical skills were assessed, together with 30 computer competencies, many non-technical and soft skills, business and math skills, and others.

Recruiting by the major companies has become very sophisticated and more demanding. Applicants are now expected to have at least a master's degree and some industrial experience. These trends reflect a need for greater competency in both geology and geophysics even though only 54% of the entire skill mix relates to geoscience topics. Recruits should also have knowledge of both geology and geophysics. The level of computer competency now required has also increased, and certain non-technical and soft skills have become essential.

Some courses offered by departments have little relevance in the oil industry. Some respondents believe university computer education may be insufficient. Education in the business areas of finance, project management, planning, and economic analysis needs to be introduced, and departments must emphasize that non-technical and soft skills are important in the work place. They should also expand their teaching efforts in the areas of ethics, summarizing, and teamwork. Companies are very willing to cooperate with departments and to help them in a number of ways.

Keywords: Education – geoscience; education – graduate; geology – employment; geology – professional affairs and public affairs.

Background

The social, economic, and political changes that have swept the world over the past decade have forced the oil industry to change its way of doing business. Because fierce competition has emerged for the new exploration, production, and other opportunities now available, companies have had to refocus on their core businesses and abandon peripheral activities. They have also had to develop new technologies and skills to exploit the new opportunities. Companies unable to adapt to change have disappeared. This industry-wide restructuring improved both efficiency and productivity, which has generally pleased shareholders. However, many employees have been forced to leave the industry because they lacked the skill mix now needed.

These changing requirements caused many geoscience departments to rethink their programs. Some revamped curricula by introducing new courses and degree formats. Others have been less responsive; partly because they were afraid of change but also because they lacked any reliable evidence that might help them make the right reforms. This could create a serious risk as any misstep would easily damage hard-earned reputations in both teaching and research.

Most students also recognized the likely consequences of these events on their own career plans. Unless they got the right education mix and appropriate qualifications, they would find it difficult to find work upon graduation. Unfortunately, students could not get reliable advice from either university career counselors or academics as most lacked relevant industry experience.

One consequence of restructuring has been that companies now need fewer domestically trained geoscientists. In addition, many companies investing in large overseas projects encountered contract terms stipulating that investors hire local geoscientists. In some cases, companies have also found third-country nationals to be better equipped to work in these locations. In addition, through increased international travel, more contact with foreign scientists, and improved Internet access, companies also discovered that they can now recruit from any of more than 3100 geology and geophysics departments worldwide. This enabled them not only to spread their recruiting net globally but also to become much more selective in their recruiting programs.

	7 Major Companies	12 Large Independents	10 Small Companies	Total
Employees – Worldwide	353,000	25,500 +	3,500 +	382,000 +
Geoscientists Employed Worldwide	4,600	1,180 +	250 +	6,030 +

Notes: Major Companies = >20,000 employees, including more than 400 geoscientists.
Large Independents = 800-5,000 employees and 100-200 geoscientists.
Small Companies = <800 employees and fewer than 100 geoscientists.

Table 1. Employment data for respondents.

To manage their recruiting process more efficiently and to reduce costs, some large companies, using various criteria, have evaluated departments regionally, nationally, or even globally. Thereafter, with few exceptions, these firms have restricted their cooperative and recruiting efforts to those departments at the top of their lists. The remaining departments could well find themselves all but abandoned unless they redesign their curricula while remaining within the limits of dwindling budgets. Students could also be affected because they would be receiving an education that no longer meets the needs of today's industry.

Objectives, Methodology, and Strategies

Having visited more than 90 departments while working for 30 years in the international oil industry, the author decided to ask oil companies to identify the skills they expect their exploration and production geoscientists to have and to share the findings with departments and their students. Since its domestic petroleum industry is both vast and scattered, a study of US based companies seemed impractical. The writer therefore focused on the most important of the international locations – Britain. At the time the survey was distributed, late 1998 to early 1999, there were approximately 45 companies located in the United Kingdom. Most were based in London or Aberdeen. These offices mainly covered North Sea operations, although some were also responsible for other countries in Europe, the Middle East and Africa.

The objectives of this study were to determine:

- the minimum geoscience degree qualification now required by petroleum companies,
- the critical geological or geophysical skills needed in the petroleum industry,
- the level of computer competency expected by these companies,
- other components of a geoscience education: specifically math and business skills,
- the significance and value of non-technical or soft skills in the workplace, and
- the possible solutions to challenges facing the geoscience community.

In this paper, non-technical and soft skills comprise a wide range of abilities, skills, and attributes possessed by geologists and geophysicists but not specifically covered by geoscience departments in the education process. Soft skills are those that appear to be innate to the individual and form part of his or her psychological makeup. Examples include such characteristics as initiative, creativity, and motivation. Non-technical skills, on the other hand, can be acquired through a range of life experiences, including education. These might include the ability to communicate, to analyze or solve problems, or to speak various languages. Together, these abilities will have a profound impact on the long-term success of the individual and upon companies who employ them.

A six-page draft questionnaire, based on data collected from previous studies, was circulated to several large oil companies for review, comment, and modification. The final text comprised approximately 120 preferential ranking exercises asking companies to assess the relative importance of numerous sub-disciplines of geology, geophysics, computer science, and non-technical and "soft" skills in their business. Additional preferential ranking exercises and open-ended questions sought information and opinions on topics not otherwise addressed in the survey. The survey was circulated to company exploration managers or senior technical managers because they ought to be familiar with both their company's technical needs and the views of their senior management.

Twenty-nine companies from twelve nations provided useable data. Most of the major firms were American owned, whereas many of the smaller ones were of British origin. Four firms declined to participate because they were either embroiled in mergers, or had already ceased to exist. A return rate of 71% seemed sufficient to make interpretations and draw conclusions that would reflect the needs and expectations of the industry as a whole. The respondents were divided into three groups or classes based upon size (see Table 1). This revealed additional traits that were unique to each class, for example, a critical need in the case of the major companies, the principal employers of young graduates.

Table 2 shows the methodology used to convert company input into an industry-wide score that could be used for ranking and comparing the relative importance of a wide range of attributes. The table also includes a legend for symbols displayed on other tables in this paper.

Some Recruiting Practices and Trends

The interview-assessment phase of recruiting is the first and crucial contact between a company and potential employees. For reasons already suggested, the last decade has seen the recruiting process become much more rigorous. However, no company was asked about any ranking system or its own recruiting policies. Instead each was asked to comment upon the following four factors that might influence its recruiting process.

- The relative importance of the reputations of both the university and the student's supervisor as well

Skill Ranking

The Skill Tables, etc. reflect the relative level of competency oil companies expect their employees to have in each technical or non-technical field.

Example of a typical calculation:
Step 1: The 12 Large Independent Oil Companies were asked to assess the level of competency required by their Geoscientists in Log/Core Analysis (petrophysics, formation evaluation, logging, and so on) by marking appropriate box. This produced the results below:

	Very High	High	Reasonable	Limited Skills	Low or Not Needed
Terrain Analysis	1	6	3	2	0

Step 2: Votes for 'Very High' competency were assigned 4 points each.
'High' votes were scored 3 points.
'Reasonable,' 'Limited Skills,' and 'Low or Not Needed' were scored 2, 1, and 0 respectively, so that:

Very High	High	Reasonable	Limited Skills	Low or Not Needed
1 x 4 = 4	6 x 3 = 18	3 x 2 = 6	2 x 1 = 2	0

Sum of scores is 4 + 18 + 6 + 2 + 0 = 30.
Maximum score possible would be 12 x 4 = 48.
30/48 = 62.5 rounded to 63%.

63 = Represents the level of competency expected. Note that this score can also be obtained by a number of vote 'mixes.'

= Indicates that all companies in the class believed that the level of competency required was either 'Very High,' High,' or 'Reasonable.'

Inter-group Trends:
Major companies have higher scores than do large independents who have higher scores than do small companies.
The reverse to the above.

Table 2. Legend for skill tables.

as that of the geoscience department and its curriculum.
The minimum geoscience degree qualification now required by employers.
The likelihood that this minimum standard would be raised.
The value of previous work experience in the assessment process.

Their responses are shown in Tables 3,4,5, and 6 respectively. It is evident from the trends of the inter-group arrows on Table 3 that major companies have higher expectations than either large independents or small firms in the areas of university and departmental reputations and the curriculum. This might reflect the vital role played by the curricula in some corporate ranking practices mentioned earlier.

Table 4 shows that most companies, particularly the larger ones, expect potential recruits to have at least an Honors degree, although most majors and large and independents prefer a Master's. Smaller companies tended to have less stringent degree requirements, perhaps because work experience is more important to them. However, Table 5 strongly suggests that the minimum qualification is rapidly ramping up to a Master's degree. Both geoscience undergraduates and department heads ignore this implication at their peril.

On Table 6, companies considered the relative importance of an applicant's pre-hiring work experience in the assessment process. Clearly, exposure to

	7 Major Companies	12 Large Independents	10 Small Companies	Inter-group Trend
Department's Reputation/ Curriculum	75	67	60	
University's Reputation	68	63	61	
Supervisor's Reputation	57	42	45	

Table 3. Relative importance of the reputations of the university, the supervisor, and that of the department and its curriculum.

Discipline	Degree	7 Major Companies	12 Large Independents	10 Small Companies	Total
Geologists	BA/B.Sc.	–	2	1	3
	Bach. Honors	2	3	5	10
	M. Sc.	5	7	4	16
	ND/Don't Know	–	–	–	–
Geophysicists	BA/B.Sc.	–	2	1	3
	Bach. Honors	2	3	6	11
	M. Sc.	4	5	3	12
	ND/Don't Know	1	2	–	3

Table 4. Current minimum degree qualifications required for employment.

Discipline	Degree	7 Major Companies	12 Large Independents	10 Small Companies	Total
Geologists	No	–	1	1	2
	Yes	2	7	5	14
	Already Is	4	4	4	12
	ND/Don't Know	1	–	–	1
Geophysicists	No	–	1	2	3
	Yes	2	7	5	14
	Already Is	4	3	3	10
	ND/Don't Know	1	1	–	2

Table 5. Future qualification requirements. Is there a trend for the minimum qualification for employment becoming a Master's Degree?

Work Experience Type	7 Major Companies	12 Large Independents	10 Small Companies	Inter-group Trend
Industry-related work experience	64	63	55	
University or government research (only 9 cos.)		—42—		
Non-industry work experience (waiter, mechanic, counter, etc.)	25	13	25	
Voluntary or community work (only 9 cos.)		—22—		
Present or past responsibilities	71	54	50	
= All companies in the class consider this form of experience to be either 'Essential,' 'Very Important,' or 'Useful.'				

Table 6. Importance of pre-hiring work experience.

	7 Major Companies	12 Large Independents	10 Small Companies	Inter-group Trend	Average
Geosciences	54	45	45		48
Computer Skills	20	22	27		23
Non-Technical & Soft Skills	26	33	28		29
Range of Non-Technical & Soft Skill Scores	15 – 40%	15 – 70%	10 – 50%		

Table 7. Industry view of the mix of geoscience, computer, and non-technical/soft skills geoscience employees need to have. (Expressed as percentages of the whole.)

industry-related work is far more important than any other sort of work, particularly for major companies. Relatively few companies were asked to consider the value of either research or unpaid work experiences. However, research experience did not seem to be particularly important to respondents: an opinion that contradicts attitudes of those academics believing research plays an important part in university education. Companies also seemed to be unimpressed by any unpaid or community work or non-industry-related work experience an applicant may have gained. Unfortunately, unskilled work is often the only sort of employment available to students trying to cover university tuition and living costs.

On the other hand, evidence that an applicant has held a position of responsibility does impress companies, particularly larger firms. Smaller companies may be more ambivalent, perhaps because they already have the leaders they need and only want scientists, preferably experienced ones.

While all of these and other factors are associated with the initial phase of recruiting, the critical part of the process comprises an assessment of the abilities or skills the applicant will need to perform the job for which s/he is being considered. These skills may be grouped into three categories: geoscience (geology and geophysics) skills, computer-related skills, and non-technical and "soft" skills. Young graduates will have acquired a very wide range of skills and experiences while growing up and being educated. But what mix of skills do oil companies really want geoscience employees to have? Their responses are displayed in Table 7. The scores shown are class averages only, although the range of opinions submitted was significant for geoscience and computer skills but even greater for non-technical and "soft" skills. Larger companies have somewhat more demanding geoscience-skill expectations than do smaller firms. However, what is perhaps of greater significance is that geoscience skills constitute, on average, only 50% of the entire skill set required in the work place. Computer scores increase with decreasing company size. The comparatively high scores for non-technical and "soft" skills data reflect the relatively high value most companies now place on employees having these skills. The range of opinions offered probably reflects each company's unique business needs, exploration and production interests, and culture as well as the attitude of the respondent. If nothing else, this table emphasizes the need for departments and students to recognize that other skills, besides geology and geophysics, must be incorporated into the teaching-learning cycle.

Geological and Geophysical Technical Skill Requirements

Geology and geophysics departments typically offer a core program of geoscience courses, augmented by a number of optional courses designed to meet the needs of employers in the geoscience community, mainly mining and oil companies, but also the public sector, including education. Yet, over the past decade the menu of career options has increased greatly, which has also changed mix of geoscience skills now required in the work place. As a consequence, some classical or basic geological or geophysical skills have become less important while the need for skills in some new disciplines has become critical. By far the most important of these relate to computer manipulation of data. The shortage of both funds and staff has made it increasingly difficult for geoscience departments to accommodate all of these demands. The expansion of curricular requirements has also made it harder for students to graduate either on schedule or debt free. If departments are to keep their programs within budget and their research alive, it seems essential that curricula remain relevant and provide training in a mix of skills that will enable students to enter meaningful careers upon graduation. Successful efforts to modernize curricula might encourage companies to support departments more actively than may have been the case in the past.

The oil companies were asked to assess the level of competency required in the 42 geological and geophysical sub-disciplines vetted by the oil companies. Introductory geology and geophysics courses, such as mineralogy, crystallography, and general geophys-

Technical and Non-technical Skills Needed by Oil Companies

Rank	Skill	G=Geophysics M=Multi-disciplinary	7 Majors	12 Large Independent Companies	10 Small Companies	Inter-group Trend
1	Sedimentology/Sedimentary Geology		89	79	75	
2	Geophysical Interpretation and Mapping	G	86	71	85	
3	Subsurface Mapping Techniques		85	81	90	
4 =	Stratigraphy		82	81	78	
	Basin Analysis/Hydrocarbon Systems	M	82	75	63	
	Sequence Stratigraphy	M	82	71	70	
7	Petroleum Geology		79	85	83	
8	Reservoir Geology		75	71	75	
9 =	Introductory Geophysics	G	71	75	68	
	Regional Geology (Basin Systems, Orogenic Belts, Nations, etc.)		71	75	63	
11	Play Assessment	M	70	85	90	
12 =	Reflect/Refraction Seismic Geophysics	G	68	56	63	
	Applied/Operations Geophysics (Methods & Acquisitions)	G	68	54	58	
14 =	Introductory Structural Geology (Principals & Deformation)		64	73	65	
	2D & 3D Modelling (Seismic Mapping)	G	64	63	68	
	Log/Core Analysis (Petrophysics, Fm. Eval., Logging, etc.)	M	64	63	68	
	Sedimentary Structures		64	54	50	
18 =	Biostratigraphy	M	61	52	43	
	Special Rock Studies – Clastics (Including Shale)		61	46	50	
20 =	Plate Tectonics/Geodynamics		57	54	50	
	Special Rock Studies – Carbonates & Evaporites		57	48	33	
	Global Geology/Geology of the World		57	46	48	
23 =	Organic Geochemistry		54	73	53	
	Adv. Struct. Geology (Struct. Analysis, Complex Struct., etc.)		54	48	58	
	Inversion Geophysics	G	54	44	40	
	Average for the top 25 skills		69	65	64	
26=	Operations Geology		50	46	58	
	Field and Mapping Skills		50	46	35	
	General Geochemistry		50	40	40	
29=	Rock: Fluid Interaction		46	56	48	
	Petrology/Petrography		46	44	35	
	General Paleontology		46	27	28	
32=	Marine Geology/Geological Oceanography		39	40	30	
	Time – Series Analysis	G	39	34	34	
34	Potential Fields (Gravity and Magnetics)	G	36	40	43	
35=	Micropaleontology (Forams, etc)		32	35	33	
	Environmental Geology		32	25	40	
37=	Palynology		29	33	30	
	Geomorphology		29	17	15	
39=	Terrain Analysis (Remote Sensing, Air Photography, etc.)	M	18	38	19	
	Coal Geology		18	15	15	
41	Recent, Quat. or Surficial Geol. (Alluvial, Coastal, Lacustrine, etc.)		16	29	15	
42	Surveying		13	17	13	
	Average for the lower 17 skills		35	34	31	

Table 8. Skills needed by oil companies. Geoscience Skills ranked according to the scores of the 7 Major Oil Companies.
• = Every company considered the level of competency required was either 'Very High,' 'High,' or 'Reasonable.'
80 = Important topics (75 or higher).

ics, were omitted from the list for the sake of simplicity.

The results are shown in Table 8. They are ranked in descending order of competency or importance according to the expectations of the major companies.

The following points seem to be significant.

The high scores of many geophysics sub-disciplines (G) reflect the importance of geophysics in hydrocarbon exploration and production activities.

Many of the skills needed by oil companies comprise a mix of geology and/or geophysics sub-disciplines. Some of these multi-discipline topics may also include components of other fields such as engineering or chemistry.

With the exception of regional geology, all respondents consider that the level of competency required in the 'top 10' topics was either 'Very High,' 'High' or 'Reasonable.' These seem to constitute the core disciplines needed in a degree program.

Both the orientation of the inter-group arrows and the class averages at the bottom of the table show that in many cases major companies have higher expectations than either large independent or small companies.

A number of classical courses are positioned in the lower half of the table. These include paleontology, geomorphology, environmental geology, and potential fields. Incorporating or excluding these from future curricula will present a considerable challenge for departments.

Departments and students can use these data in similar ways. By reading the data vertically, departments can redesign curricula to produce either a top-quality petroleum geology degree or at least a foundation program for that field. Likewise, students can generate course-taking strategies directed at helping them enter the hydrocarbon industry by taking only those courses set in the upper part of the table. Both groups can easily identify the possible curriculum and career consequences of offering or taking low-scoring courses.

A key component of good geoscience education has always been the ability to observe, record, collate, and interpret data obtained in the field. The need for proper field training was emphasized by the mining companies in the Canadian study. However, unlike mining, offshore and onshore hydrocarbon exploration or production activities tend to focus on understanding the characteristics of rocks located at considerable depth and remote from outcrops. The efforts of geoscientists to do this have been aided by the development of sophisticated technologies such as 3-D geophysical processing and the like. Given this scenario, is field training still important to British-based oil companies? To find out, the companies were asked how many days of training were sufficient. Table 9 shows their reaction. While there was a wide range of opinions, the overall average was about 60 days, somewhat less than the Canadian figures where there is much more onshore activity which is closer to the outcrop. Departments are facing serious problems in delivering proper and sufficient field and mapping training, in part because the cost of training has become increasingly difficult to cover. To help offset this shortfall, most students must now pay special fees for field school. Another problem facing departments relates to the possible legal consequences should a student get injured while on a field trip. Some universities have been successfully sued in student-injury cases. If companies want their employees to have these skills, it may be in their best interest to help departments offset some of these training costs. More transferable than geology and geophysics skills are those related to computer science.

Number of Days Preferred	7 Major Companies	12 Large Independents	10 Small Companies	Total
0 – 20	1	–	–	1
21 – 40	1	1	5	7
41 – 60	2	3	2	7
61 – 80	2	4	–	6
81 – 100	–	2	2	4
>100	1	2	1	4

Table 9. Field and mapping training/experience.

Computer Competence

The development of computer technology has had a profound impact upon the oil industry and today every phase of oil-company operations involves data manipulation using computers. Consequently, without proper education in computer sciences, it will be all but impossible for geoscience graduates to get jobs in the oil industry. To identify and rank company needs, respondents were asked to assess the level of competency required in thirty facets of computer operations. Twenty were grouped in seven "basic operations": each comprising introductory and advanced levels of knowledge. The remaining ten topics consisted of geoscience-specific operations related to exploration and production activities. Corporate reactions are shown on Table 10. Few scores exceed 60. This may reflect the reality that explorationists need to have greater expertise in geology and geophysics than they do in computer science. Thus, young geoscience graduates need not be experts in computer science, but they must have sufficient knowledge to understand what computers can do for them and how a company's computer support staff can help them in their work.

It would seem reasonable for departments to expect students to have gained some experience in the basic computer operations prior to joining the department, principally in the areas of electronic communications, desktop systems, word processing, and the Internet. Therefore, departments should have to do little more than identify how these operations apply to geology and geophysics. However, departments need to dedicate more time to the following:

spreadsheets (Lotus),
knowledge of PC or Unix hardware,

Basic Operations		7 Majors	12 Large Independent Companies	10 Small Companies	Inter-group Trend
	Spreadsheets (Lotus, Excel, etc.)	75	73	81	
	Electronic Communication (e-mail)	75	73	75	
	Desktop Systems (Windows '95, Mac, etc.)	75	69	75	
	Word Processing (Word, WordPerfect, DOS, etc.)	64	69	64	
Hardware	PC	68	60	69	
	Unix	68	58	58	
	Exposure to Periferal Equipment	31	46	44	
Internet	Searching (www, Yahoo, Accessing Indexes, etc.)	46	54	56	
	Application (FTP, Telnet, etc.)	43	42	31	
Programming	Introduction (C++, FORTRAN, html, etc.)	25	18	13	
	Advanced (C++, FORTRAN, html, etc.)	25	18	13	
Data Bases	Simple (Foxpro, Access, Dbase, Paradox, etc.)	36	40	25	
	Advanced (Oracle)	29	29	22	
	Design & Management	8	27	11	
Graphics	Presentation (Power Point, etc.)	64	60	58	
	Advanced (Corel Draw, etc.)	29	31	36	
	Drafting (Autocad, Visio, etc.)	21	19	19	
GIS	Simple (Arc View, Map Info, etc.)	43	42	44	
	Advanced (Arc Info, Span, etc.)	25	23	22	
	Assisted Modelling (Fuzzy Logic, Weights of Evidence, etc.)	18	16	19	
Geoscience Specific Operations					
	Exposure to interp. systems (Landmark, Promax, Datamine, Geosoft, etc.)	68	58	58	
	Resource/Reserve Calculations (GSLIB, etc.)	50	50	53	
	Geophysical Modelling (Seismic and potential field data)	50	44	53	
	Geological Modelling (PC-Xplor, Rockware, etc.)	50	35	50	
	Statistical Data (SAS, etc.)	50	42	50	
	Geophysical Processing (Geosoft, ER Mapping, etc.)	46	38	53	
	Geochemistry – Applications (Paradox, Excel, Rockware, etc.)	36	42	42	
	Geochemistry – Spatial (Geosoft, Arc View, Surfer, etc.)	36	27	22	
	Exploration & Mapping Packages (Vulcan, Datamine, Micromine, etc.)	32	36	28	
	Remote Sensing (Terrascience, ER Mapper, Arc Grid, etc.)	14	27	25	
Average Score		45	40	43	

Table 10. Computer skills needed by oil companies. Skills ranked according to scores of the 7 Major Oil Companies. • = Every company considered the level of competency required was either 'Very High,' 'High,' or 'Reasonable.' 65 = Important scores (60 or higher).

graphics, particularly presentation graphics (Power Point and so on),
some exposure to interpretation systems (Landmark, Promax, DataMine and so forth), and
geographic information systems (Arc View, Map Info, and so forth).

Within the basic groups, the erratic orientation of the inter-group arrows suggests that the level of computer competencies required has little relationship to company size. However, within most groups, larger firms seem to want employees to have somewhat more advanced levels of competency than do smaller firms. Of the geoscience-specific operations, only 'Exposure to Interpretation Systems' received high scores, particularly from the major firms.

Past geoscience student and alumni surveys taken in Britain and Canada revealed that many were dissatisfied with their university computer education. Part of the problem may be that departments lack funds to buy the latest hardware and cannot keep abreast of the rapidly evolving software programs.

Math and Business Education

Topic	7 Major Companies	12 Large Independents	10 Small Companies	Average
1 year of Geostatistics	57	37	50	48
Applied Math	54	33	47	45
Classical Statistics	43	36	48	42
1 year of Calculus	36	23	25	28
2 years or more of Geostatistics	29	25	40	31
Advanced Geostatistics (Krieging, Variograms, etc.)	29	33	28	30
2 years or more of Calculus	29	21	23	24

Table 11. Math education.

	5 Major Companies	12 Large Independents	10 Small Companies	Average
General Business Awareness	50	42	63	52

Table 12. Importance of business education.

The advent of computer technology has eliminated the need for geoscientists to make the many mathematical calculations required in the past. Historically, the higher quality geoscience departments expected their students to take at least two years of university mathematics, more if they aspired to be geophysicists. These courses usually included one or two years of calculus. Is this emphasis on mathematics still warranted? If so, what aspects of mathematics should be covered? Table 11 outlines the view of the oil companies. As can be seen, firms still want students to take at least one year of mathematics. However, they favor statistics, preferably geostatistics, over calculus. Two years of calculus seem unnecessary, and in fact, scores for any two-year mathematics program are quite low. No effort was made to determine what math training geophysics students should receive, but in a separate study currently underway, companies report that they expect geophysics graduates to have taken two years or more of mathematics, including at least one year of calculus. They also prefer a course in applied mathematics to geostatistics.

In Heath's previous studies, a number of companies had observed that many young employees lacked awareness of business principals and practices. This issue has been the subject of considerable discussion in the media as well. In his 1998 article in the British Geological Society's Geoscientist magazine, Wade reported that this deficiency had contributed to the relatively low employment rate of recent British geoscience graduates. In Heath's Canadian study, respondents asked for their reaction to the idea that a business course should be included in geoscience curricula. The 26 mining companies supported the idea with a score of 77 while the score for the 7 oil companies was 86. Because these figures exceeded scores received for many of the geology and geophysics disciplines, the author asked British-based oil companies for their opinions. Table 13 shows that these firms also support this idea – but not to the degree claimed by Canadian-based firms. Table 14 ranks six possible topics that could be included in such a course. As was the case in Canada, support is greatest amongst the small companies. Project management, planning/strategy, and economic analysis were the most popular suggestions, although major firms also valued finance/budgeting skills. As will be shown in the next section, a business program could also cover ethics.

Topic	7 Major Companies	12 Large Independents	10 Small Companies	Inter-Group Trend	Average
Finance/Budgeting	54	36	50		47
Project Management	50	52	58		53
Planning/Strategy	50	47	53		50
Economic Analysis	46	52	58		52
Some Business Courses	39	43	48		47
Some Knowledge of Law/Contracts	14	25	35		24
Average	42	46	53		
No Data	2	1	0		

Table 13. Business education – possible topics. Ranked according to scores of the Major Oil Companies.

Non-technical and Soft Skills

Perhaps as little as a decade ago, recruiters tended to focus their assessments on technical skills, work experience, and to a lesser extent, on computer skills. They also tried to determine if the candidate would adapt to the corporation's culture. At times this exercise seemed rather informal and even a little haphazard. Non-technical and soft skills were almost ignored. As suggested earlier (Table 7 and related passages), the assessment process has now become much more sophisticated, and companies now recognize the important roles that good non-technical and "soft" skills play in their business dealings. These skills become crucial as companies move beyond domestic borders into countries where value systems, beliefs, and cultures are often very different. Since most of the British-based companies had international interests, they were asked to assess the relative importance of 34 non-technical and "soft" skills. The topics chosen were based upon findings made by Harvey and Green (1994) but later modified by the author's findings from studies of the resource sector. While each capability has been defined by one or two words, it seems likely that the boundaries between the attributes are very blurred and the interrelationships diffuse. The company responses are shown in Table 14.

Skill	7 Majors	11 Large Independent Companies	10 Small Companies	Inter-group Trend	Teaching Process does (3) or should (x) enhance.
Initiative	93 ●	93	80		
Ethics/Integrity	93 ●	91	85		X
Willingness to Learn	93 ●	86	78		
Adaptability/Flexibility (Job, Location, Organization, etc.)	93 ●	84 ●	83		
Commitment	89 ●	89	85		
Can Summarize Key Issues/Abstract	89 ●	88 ●	83		X
Desire to Achieve/Motivation	89 ●	86 ●	85		
Cooperation	89 ●	86 ●	83		
Analytical Skills	89	86 ●	78 ●		3
Can Cope With Stress	89 ●	84	83 ●		
Drive/Energy/Enthusiasm	86 ●	91 ●	85		
Dependability/Reliability	86 ●	84	88		
Self-Management/Self-Control	86	84 ●	83		
Teamwork	86 ●	82	73		X
Listening	86	82	70		
Taking Responsibility/Self-Reliance	86	79	78		
Problem-Solving Ability	86	77	80		3
Time Management	86	68	83		
Oral Communication	82 ●	84 ●	83 ●		3
Logical Argument/Reasoning	82	82	75		3
Self-Confidence	82	75	70		
Research or Enquiry Skills	82	67	73		3
Cultural Flexibility/Awareness	82	56	70		
Creativity/Out-of-the-Box Thinking	79	79	80		
Can Overcome Adversity	79	77	68		
Intellectual Ability/Intelligence (Hons., Good grades, cum laude, etc.)	79	55	65		3
Written Communication	75	75	80		3
Rapid Conceptualization of Ideas	75	73	68		
Spatial thinking/3-D visualization	75	66	70		
Leadership (Past Responsibilities, etc.)	71	68	60		
Entrepreneurial Flair/Skills	68	68	60		
Numeracy	68	50	58		3
International Living/Travel Experience	64	46	53		
Risk taker	57	59	65		3
Language (Non-Native) Skills	50	38	56		

Table 14. Skills needed by the oil companies. Non-technical and soft skills – ranked according to the scores of the 7 Major Oil Companies.

Despite these ambiguities, the data reveal the following.

The high scores demonstrate the importance of these skills in the eyes of employers.

The widespread distribution of the ( ) symbols shows that skills were particularly important to the major companies and the large independents.

This characteristic is emphasized by the direction of the inter-group trend arrows.

Most of the top 15 attributes seem closely linked to innate skills or the attitudes of the students

Strengths
(29 companies provided 29 opinions).

Topic	Votes
Good basic program	12
Improving or good computer education	5
Master's & PhD graduates have sufficient skills	3

Weakness
(22 companies provided 36 opinions).

Topic	Votes
Non-technical and soft skills	8
Business awareness	6
Petroleum geoscience education	5
Computer education	4
Introduction of new technologies	4

Table 15. Corporate views on the quality of geoscience education.

themselves. One wonders if students are ever made aware of this.

Smaller companies place somewhat less emphasis on non-technical and "soft" skills, perhaps reflecting their preference for technical expertise, training, and experience over other factors.

In 19th and 27th positions, oral and written communications seem relatively unimportant. Yet many CEOs have complained that young people have poor communication skills.

Many academics place considerable emphasis on student skills in research, intellectual ability (good grades), written communication, and numeracy. Yet these are ranked 22nd, 26th, 27th, and 32nd respectively.

Some skills thought to be critical when working in a global economy also fare very poorly. Cultural awareness is 23rd, while international living ranks 33rd and non-native language skills are last in 35th place.

Governments, business executives, and the media often call for more encouragement for those exhibiting creativity, entrepreneurship, and risk-taking skills. Yet, these three attributes, placed at 24th, 31st, and 34th respectively, were generally downplayed by most respondents, apart from small companies. Given the risky nature of the oil (and mining) business, one has to wonder to what degree larger companies really value these attributes and how they manage and reward people exhibiting these apparently low-value traits.

Several low scores also conflict with statements made by executives or recruiters interviewed. For instance, American executives said that knowledge of a second language was important for those working in overseas locations, yet languages and other global-oriented skills scored very poorly. Why is this? Are executives failing to get their message through to their recruiters? Perhaps some executives make these claims because it is the correct thing to say without knowing why these skills are important? Clearly, these mixed signals will not motivate department heads to redesign their curricula to include some global skills.

The low score attributed to research and enquiry agrees with the data shown on Table 7. This reaction agreed with those of the mining and oil companies surveyed in Canada.

Many in industry have a low opinion of much curiosity-driven research carried out by universities because the subjects studied often seem to have no practical application.

Intellectual ability (good grades and so on) also scored relatively poorly. This seems to conflict with attitudes of both academics and recruiters. Both seem to recognize that good grades reflect an applicant's potential capability in some way. However, grade inflation in some universities has caused some recruiters to pay less attention to grades than in the past. How widespread this problem is, is unclear, although it must reflect poorly on departments.

These apparent contradictions could be the subject of useful discussions between faculty, department heads, employers, and other members of the geoscience community.

So what role should the education process take in developing or enhancing non-technical and "soft" skills? As shown on Table 14, many of the critical skills required in the work place seem to be innate. At best, the university should provide an environment where these attributes can blossom. Other skills, such as coping with stress and time management, are developed by the student as s/he progresses through life and the education process. The ticks in the table's right-hand column represent the author's assessment of where faculty, through the teaching process, contribute most to the development of non-technical and "soft" skills. Most lie in the middle and lower part of the table. However, there are three areas, here marked by Xs, where instructors should place more emphasis than they may do at the moment: ethics, abstracting, and teamwork.

Implications of the Survey Findings

Respondents were asked to identify the strengths and weaknesses of the geoscience education process. The input from those who replied is shown on Table 15. Only the most frequently made comments are listed, although the variety of comments was quite diverse. On the positive side, many thought that the basic geology and geophysics degree programs were good. Some thought that the computer education was improving and that the Master's and PhD programs now provide students with sufficient geoscience education for entry into the oil industry. On the other hand, many complained of the lack of education in non-technical, "soft," and business education while others thought that computer education was insufficient. Clearly, companies have conflicting views on the quality computer education of young employees. (Students and alumni tended to blame universities for this.) Training in certain aspects of petroleum geo-

Support Type	17 British-Based Companies (1999)	42 Canadian-Based Companies (2000)
Direct		
Funding – Chairs, Prizes, Equipment, etc.	21	41
Provide Leadership – Field Trips, Mentoring, etc	17	38
Exposure to Business	62	103
Education – Business Related Lectures, Course Design, etc.	15	52
Research		
Non-Thematic [Basic] Research	0	10
Frontier Development or Thematic [Applied] Research	22	~93
Totals	137	337

Table 16a. Potential mining and oil industry support for departments (1999, 2000 studies).

Area of Possible Support	
Provide Internships	10
Visits, Mentoring, Career Days, Lectures	9
Sponsor Research (Thesis?) Projects	7
Increase Company : University Dialogue	6
Total	32

Table 16b. Possible support suggested by British-based oil companies. (21 companies provided 36 possibilities.)

science were also considered weak by some. Other firms wanted students to be aware of new developments in technology.

A review of the data presented in this study identifies a number of the factors that need to be taken into consideration when upgrading geology and geophysics programs. Some of these are listed below.

Students need to be given better advice concerning both the courses they should take to pursue career objectives and the realities of working in today's resource industry environment.

Most oil companies hiring graduates regard a Master's degree as the minimum qualification for employment.

All geology and geophysics graduates wanting to enter the oil industry must have knowledge of both disciplines. They need to be geoscientists rather than specialists. This may apply to research candidates as well because most research now has strong multi-disciplinary components.

The undergraduate curriculum is too time constrained to provide more than an overview of petroleum-related subjects. However, some quasi-specialized courses ought to be introduced in third and fourth years. The same applies to mining where a different mix of sub-disciplines is required.

The mathematics taken needs to include more statistics, or geostatistics, and in the case of geologists, less calculus.

Computer education needs to be upgraded to include exposure to both interpretation systems such as Landmark and current geoscience-based software packages.

A course covering basic business skills, including ethics, project management, planning/strategy, and economics analysis needs to be incorporated into geoscience curricula.

Team teaching and other initiatives might better demonstrate the inter-relationships existing among certain disciplines, particularly for the multidisciplinary topics cited on Table 8.

Previous student surveys (1999, and 2000) suggested that many courses tend to contain too much theory and too little applied material. Companies tend to agree.

Pre-hiring industry-related work experience is also critical. Co-op programs and other university-industry linked initiatives will help provide this. However, some non-skilled jobs do enhance certain "soft" skills.

Much more effort needs to be made by faculty to emphasize the importance of non-technical and "soft" skills in the work place. This is particularly true in the areas of ethics, summarizing, and teamwork.

Departments and student alike would benefit from closer links with employers. Visits by speakers from industry to talk about the business environment and the practical applications of certain disciplines would help. Improved university-industry connections may result in departments getting consulting contracts and more involvement in industry research through establishment of strategic research partnerships. More students may get hired for summer work or permanent jobs as well.

The issue of curriculum reform applies to the mining industry as well, although there are some differences.

Industry-University Cooperation

Industry has a strong role to play in geoscience education reform. Any changes initiated by departments are likely to cost money. Government political and financial support has often been inconsistent, so departments will have to look elsewhere for help. Since employers are the most likely beneficiaries of reforms, they ought to be willing to help. Money will be needed to cover the cost of hiring or retraining instructors for team teaching of multidisciplinary topics and the purchase of equipment required for new research and degree programs. In earlier surveys, companies were asked to identify ways in which they might help departments. The twenty possible options were suggested and listed in descending order from the most expensive, such as supporting a chair, down to the cheapest, but perhaps more time consuming ideas, such as helping develop a new course. Respondents were assured that their participation in no way committed them to follow through on their comments. Table 16a is a compilation of their input grouped under general headings. Clearly, companies seemed willing to help if approached in the right way. However, some firms expressed concerns about the poor management of certain research projects, the occasional lack of transparency and insufficient communications between some faculty and donors. As the data on Table 16b shows, the British-based oil companies were also willing to help although this part of the survey was much less detailed.

Conclusions

The repertoire of skills oil-company employees are expected to possess has changed considerably over the last decade. Departments need to adjust their curricula so that students have the skills needed to get suitable jobs upon graduation. If departments fail to carry out reform, companies will look elsewhere for both recruits and strategic partners for research projects. Inaction would not only threaten the survival of the departments but also that of their faculty and student body. It is imperative that departments and geoscience-based companies work together to address the issues facing tertiary education in geology and geophysics. The outcome will benefit departments, employers, students, and society as a whole. The same applies in the area of research: a key component of a university's responsibilities and its raison d'etre. While governments may continue to fund non-thematic, basic or curiosity-driven research, companies are often reluctant to support such work for a number of reasons. However, this hurdle might be overcome were departments, governments, and companies able to better understand each other's needs and expectations.

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