

INGREDIENTS FOR A FIRST DEGREE GEOLOGICAL EDUCATION¹

Results of a questionnaire

H. E. RONDEEL²

INTRODUCTION

In March 1979, a questionnaire was sent out to earth scientists in The Netherlands in order to obtain their opinion about the importance of certain skills and attitudes (Table I) on completion of a first degree in geology. In principle no attention was paid to knowledge in itself, nor was attention focused on skills within subdisciplines of the earth sciences.

The questions were phrased by the Geological Education Working Party in the European Community (GEWPEC). The questionnaire was sent to a large number³ of earth scientists, accompanied by a copy of a report (Nieuwsbrief KNGMG 1978 (7): 4-5) on the GEWPEC meeting in London at which it was decided to set up a questionnaire for distribution throughout the EEC.

THE RESPONSE GROUP

Figure 1 presents a listing of the 139 respondents in subgroups according to educational level, country of education and employment. It was thought that a relation might exist between subgroups and the value attached to specific skills or attitudes. This opinion proved to be wrong (see further the notes on cross tabulation).

RESULTS

The main results of the questionnaire are contained in the tables II and III which present a ranking according to the mean of the value attached to the skills and attitudes. The ranking order does not change substantially if it is based on the total percentage of respondents who values the items as essential and important. The latter data are also included in the tables II and III. They can be used to make a comparison with the outcome of a questionnaire distributed throughout

the USA in 1969 and published in 1970 by the Council on Education in the Geological Sciences (CEGS) of the American Geological Institute (REEVES & DELO, 1970). Table IV summarizes some of the results of that collection of opinions.

In so far as the items of the two questionnaires can be compared, they usually rank about equally high. Only the items 'Graphic communication' and 'Computer programming' rank much lower in the outcome of our questionnaire than in that of the CEGS.

Cross tabulation

A complete cross tabulation has been carried out between respondent subgroups and the individual items. Cross tabulation in general does not show a relationship between the responses on individual items of the subgroups distinguished on the basis of educational level, country of education and employment, and depicted in figure 1.

EDUCATIONAL LEVEL	COUNTRY of EDUCATION	EMPLOYMENT	
			M I S S I N G
	OUTSIDE NL	GOVERNMENT	12.2
		UNIVERSITY	22.3
		ORE	2.9
			7.9
DRS			20.9
	NL	OIL	
DR			46.8
			69.8
			51.8
			PUBLIC
			INDUSTRY

Fig. 1 Listing of respondents (n = 139) according to educational level, country of education and employment. Numbers indicate percentages of respondents.

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²Geological Institute, University of Amsterdam, Nieuwe Prinsengracht 130, AMSTERDAM, The Netherlands.

³Notes on response relations are contained in Rondeel (1979) that is supplied upon request.

Table I
The skills and attitudes of the questionnaire.

Please rank the skills and attitudes below according to the following system:

- 5 = Very important
- 4 = Important
- 3 = Quite important
- 2 = Little important
- 1 = Not important

SKILLS

1. Ability to use geological literature in at least two modern languages other than ones native language.
2. Ability to communicate orally.
3. Ability to write a report on work carried out.
4. Ability to synthesise and analyse publications.
5. Ability to participate in a discussion on geology.
6. Ability to understand and handle numerical data.
7. Ability to conduct a project (i.e. formulation of a problem and attempt to solve it).
8. Ability to construct a geological map (at a scale of 1:10,000) from first-hand observations.
9. Ability to communicate effectively in a graphical form.
10. Ability to describe concisely fundamental earth materials (i.e., crystals, minerals, rocks and fossils).
11. Ability to recognize in hand specimen and/or thin-section the fundamental earth materials.
12. Ability to recognize and describe, using technical terms, fundamental structures (i.e., faults, folds, boudins, foliations, lineations, and joints).
13. Ability to interpret and summarize the data from geological maps on scales of 1:10,000 and 1:50,000.
14. Ability to use a petrological microscope.
15. Ability to use simple geophysical equipment.
16. Ability to use a point-counting device to obtain a mode of a rock.

However, a relationship certainly exists between the following, as demonstrated at the 5% level of significance.

(a) Educational level and '1:10,000 mapping' (skill 8), 'computer programming' (skill 25), and 'readiness for interdisciplinary co-operation' (att. 5). Doctorandi value skill 25 and att. 5 higher, but skill 8 lower than the respondents of the Dr-subgroup.

(b) Country of education and 'literature in two languages' (skill 1) and 'value and selectivity of geological observation' (att. 11). Respondents educated in The Netherlands value skill 1 much higher than others, but they value att. 11 lower.

(c) Employment and 'fundamental structures' (skill 12), 'new developments' (att. 9) and 'value and selectivity of geological observation' (att. 11). Industry in general, i.e. the respondent subgroup from oil, ore and other industry together, value these three items higher than respondents from universities and public servants together. It is especially the group of public servants that strongly influence this outcome. Not only with respect to skill 12 and att. 11, but also

17. Ability to calculate a norm of an igneous rock.
18. Ability to use univariate statistics.
19. Ability to use X-ray equipment.
20. Ability to make basic photogeological interpretations.
21. Appreciation of multivariate statistics.
22. Ability to think in three dimensions in space and time.
23. Ability to retrieve information relevant to the earth sciences.
24. Ability to use relevant aspects of the physical, chemical and biological sciences, and mathematics for studies in geology.
25. Ability to write simple computer programmes.
26. Ability to study a geological subdiscipline to the frontiers of knowledge.

ATTITUDES

1. Appreciation of the nature of truth.
2. Appreciation of the differences between observation and interpretation.
3. Development of a constructive critical attitude.
4. Openness for co-operation, teamwork and exchange of information within geology.
5. Readiness for interdisciplinary co-operation.
6. Readiness to test formal theories for use in geology.
7. Awareness that geology requires a particular standard of training in complex thinking and of wide-ranging knowledge in different fields.
8. Affection for the geological sciences.
9. Eagerness to learn about new developments in the field of geology.
10. Openness to new aspects of geology (i.e. continuous learning and relearning).
11. Appreciation of the value and selectivity of geological observation.
12. Appreciation of scale.
13. Appreciation of the scale of time.
14. Appreciation of the principles of uncertainty.
15. Appreciation of the historical development of and the methodology of the earth sciences.
16. Awareness of the economic, political and social consequences of the application of geological knowledge.

with 'numerical data handling' (skill 6), 'complex thinking' (att. 7) and 'scale' (att. 12) is their response significantly lower in value than from any other subgroup.

Comments

Comments were solicited on the questionnaire. Respondents were also asked to add further skills and attitudes considered to be of importance in a first-degree geological education. The response on this subject has been compiled in a separate note (RONDEEL, 1979) that will be supplied upon request. This note also contains the results of an enlarged questionnaire in which the number of skills was brought to 50 and to which 46 employees of an oil company responded. It is only remarked here that the results of this enlarged questionnaire show structural geology and tectonics with four out of the seven highest scoring items (mean > 4.0) and sedimentology with two items in this group of seven. These items evidently are considered most important in the 'oil field'.

Table II
Data on the response on skills (n = 139), ranked by mean. Number between brackets indicates skill number.

	Mean	Stand. dev.	Percentage of respondents who valued the items as		
			Essential	Important	Missing
1. Four-dimensional thinking (22)	4.75	.55	79.9	15.8	.0
2. Report writing (3)	4.69	.54	71.9	23.7	.7
4.5					
3. Map synthesis (13)	4.44	.73	58.3	26.6	.7
4. Conducting a project (7)	4.35	.72	47.5	39.6	1.4
5. Synth. & Anal. literature (4)	4.31	.74	47.5	35.3	.7
6. 1:10,000 mapping (8)	4.31	.82	50.8	33.8	.0
7. Fundamental structures (12)	4.25	.79	45.3	34.5	.0
8. Oral communication (2)	4.16	.75	36.0	43.9	.7
9. Earth materials: recognition (11)	4.06	.90	38.1	33.8	.7
10. Information retrieval (23)	4.05	.75	26.6	50.4	3.6
11. Literature in two languages (1)	4.04	.97	39.6	29.5	2.2
4					
12. Earth materials: description (10)	3.99	.92	36.0	30.9	1.4
13. Discussion (5)	3.99	.79	27.3	46.0	.7
14. Use relevant sciences (24)	3.96	.78	26.6	43.2	1.4
15. Graphic communication (9)	3.83	.77	17.3	51.1	1.4
16. Numeral data handling (6)	3.75	.79	17.3	42.4	1.4
3.5					
17. Use petrol. microscope (14)	3.49	.98	15.8	32.4	2.9
18. Photogeological interpretation (20)	3.46	.88	10.8	36.7	2.9
19. Study subdiscipline to frontiers of knowledge (26)	3.24	1.09	10.8	29.5	6.5
20. Univariate statistics (18)	3.13	.95	7.9	23.0	3.6
3					
21. Multivariate statistics (21)	2.99	.88	4.3	22.3	2.2
22. Use geoph. equipment (15)	2.70	.93	2.9	15.1	3.6
23. Computer programming (25)	2.52	.97	2.2	15.1	2.2
2.5					
24. Use point counter (16)	2.44	.94	3.6	9.4	6.5
25. Norm calculation (17)	2.33	.92	2.9	8.6	7.2
2					
26. X-ray equipment (19)	1.99	.96	1.4	6.5	5.0

Table III
Data on the response on attitudes (n = 139), ranked by mean. Number between brackets indicates attitude number.

	Mean	Stand. dev.	Percentages of respondents who valued the items as		
			Essential	Important	Missing
1. Difference observation-interpretation (2)	4.83	.40	82.0	15.1	2.2
2. Nature of truth (1)	4.51	.73	55.4	24.5	11.5
4.5					
3. Constructive criticism (3)	4.48	.64	53.2	35.3	4.3
4. Permanent education (10)	4.37	.70	47.5	35.3	5.0
5. Value & selectivity geol. observ. (11)	4.35	.68	43.9	41.0	4.3
6. Co-operation (4): openness	4.24	.68	36.0	45.3	5.8
7. Learning new developments (9)	4.23	.71	36.7	45.3	4.3
8. Scale appreciation (12)	4.22	.77	39.6	38.8	4.3
9. Interdiscipl. co-operation (5): readiness	4.22	.72	37.4	42.4	3.6
10. Scale of time (13)	4.20	.78	39.6	39.6	2.2
11. Principles of uncertainty (14)	4.16	.82	35.3	43.2	5.0
12. Affection for geology (8)	4.04	.98	38.8	26.6	5.0
13. Awareness complex thinking (7)	4.01	.81	26.6	44.6	6.5
4					
14. Formal theories testing (6)	3.65	.76	12.9	40.3	4.3
3.5					
15. Consequences of knowledge (16)	3.48	1.14	21.6	25.9	4.3
16. Historical development and methodology (15)	3.25	.93	10.8	23.0	3.6

Table IV
Most useful items for their current (and future) work as derived from the 1969 CEGS questionnaire (after Reeves & Delo, 1970).

		Rank of most useful item for future work	
(95%)	1. Technical writing	1	(93%)
	2. Library research & reference material	2	(91%)
(90%)	3. Graphic representation of data	3	(89%)
(85%)	4. Map interpretation methods	5	(85%)
	5. Computer programming	4	(88%)
(78%)	6. Geol. field mapping methods	6	(80%)
	7. Geological time scale	8	(75%)
	8. Sed. rock classification systems	7	(76%)
	9. Description and classification of geological structures	10	(72%)
	10. Hand specimen identification of rocks	9	(73%)
	11. Determination of stratigr. units	11	(71%)
	12. Sampling design & procedure	12	(71%)
(70%)	13. Interpr. of sedim. environments	13	(70%)
	14. Transport of sediment	14	(70%)
	— Fluvial and lit. eros. & depos. proc.	15	
	15. Hand specimen ident. minerals	16	(70%)
	— Data storage and retrieval	17	
	16. Reg. stratigraphy N. America	19	(69%)
	17. Sedimentary environments	20	(67%)
	18. Photogramm. & air-photo interpr.	18	(69%)
	19. Textures & struct. of rocks	22	(66%)
	20. Construction of struct. cross sections	21	(66%)
	21. Subsurface mapping techniques	23	(65%)
	22. Natural mineral assemblages	24	(64%)
	23. Trigonometry	28	(62%)
	24. Basic calculus	25	(64%)
	25. Field study of major structures	29	(62%)
	26. Stratigraphic field techniques	30	(62%)
	27. Isopach & facies models	27	(62%)
(60%)	28. Modes of occur. & rock associations	32	(61%)
	29. Optical mineralogy & petrography	31	(61%)
	30. Primary sedimentary structures	34	(59%)
	31. Influence of tectonics on stratigraphy	26	(63%)
	32. Provenance of clastics	36	(58%)
	33. Palaeogeog. & palaeogeol. maps	33	(59%)
	34. Palaeoenvironments	35	(58%)
	35. Diagenesis of non-carbonate sediments	37	(57%)
	36. Drilling techniques	38	(55%)
(50%)	37. Borehole logging techniques	39	(53%)

CONCLUSIONS

The result of the response to the questionnaire can be summarized by stating the educational priorities for a first degree as felt by the respondent group.

The need for *communicational abilities* is strongly felt as reflected in the ranking of 'report writing' as second, 'oral communication' as eighth, 'discussion' as thirteenth and 'graphic communication' as fifteenth.

The ability of '*four dimensional thinking*' cannot be overstressed. It not only ranks first, but its influence is in my opinion also felt in the high value given to 'map synthesis' and '1:10,000 mapping'. Still, these latter items also depend to a large extent on *synthesising abilities* that also are incorporated in fifth ranking skill 4 that deals with literature. Also incorporated in this skill 4 is *retrieval of information*, an item (skill 10) that in itself scores tenth.

It is remarked that the outcome of the 1969 review in the USA (see Table IV) shows a similar picture.

All skills that are directed towards a specialism in the geological sciences have a score that is much lower than those of more general concern, while 'the study of a subdiscipline to the frontiers of knowledge' also fails to attain a high score. In my opinion it signifies that *specialisation* is felt to be of *little importance* in a first degree in geology.

The *attitudes* — a few excepted — are all considered of *immediate relevance*. It seems a necessity for the geological education departments to appreciate this fact and to try to open up systems for the development of attitudes in students.

It is now up to the universities to put to effective use the opinions expressed in response to this questionnaire when embarking on a reprogramming of their curricula as requested by the Ministry of Education.

REFERENCES

- Reeves, R. E. & D. M. Delo (eds.) 1970 Requirements in the field of geology — CEGS Progr. Publ. 5, Council Educ. Geol. Sci. (Washington).
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