

Testing Generative Rather Than Convergent Thinking with Open-ended Tasks

This paper considers the use of open-ended assessment tasks that test generative thinking as distinct from closed tasks that test convergent thinking. The notions of generative and convergent thinking are defined. It is argued that generative thinking is as useful a concept for analysing and understanding test items as the ubiquitous notions of problem solving and critical thinking. Open writing test prompts that contrast with convergent writing tests, and open-ended short answer questions that contrast with closed short answer (and most multiple choice) questions are examined. Examples of open assessment tasks that test generative thinking are drawn from the Writing and the Short Answer Question components of the ACT Scaling Test.

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Testing Generative Rather Than Convergent Thinking with Open-ended Tasks

The most commonly noted weaknesses of educational assessments are:

- too much testing of recall of facts and information without demonstration of understanding;
- too little testing of the application of knowledge; and
- too little testing of reasoning and critical thinking.

It is not commonly recognised that a limited range of thinking and a preponderance of convergent thinking is tested in educational assessments. In this paper I will outline an interpretation of the concept of generative thinking as an introduction to some assessment materials that aim to test generative rather than convergent thinking. My aim is to show that the notions of generative and convergent thinking offer a useful basis for analysing educational assessments.

What is meant by generative thinking?

Generative thinking involves the production of ideas as distinct from convergent thinking. Convergent thinking involves the analysis of a definite and particular problem to determine a unique or a limited number of correct answers. Generative thinking is required to answer open questions whereas convergent thinking is required to answer closed questions. Closed questions have one or a limited number of correct answers. Open questions do not have correct answers. Assessing responses to open questions involves qualitative judgements made on the basis of criteria and reasons.

J. P. Guilford, who developed the structure of intellect model of cognition in the 1950s and 60s, used the terms convergent and divergent in his research on creativity¹. Guilford saw divergent thinking as involving the generation of original views or multiple solutions to problems. Convergent thinking, on the other hand, meant thinking that is constrained by the terms of a task or a problem, and such thinking would often involve a unique or a limited number of possible solutions to a problem. Guilford recognised that cognitive testing was commonly limited to convergent thinking.

The notion of convergent thinking is a useful term for describing a style of logico-deductive thinking. The term divergent thinking, on the other hand, seems an inappropriate term for describing open-ended thinking. Similarly, the term 'creative' is to be eschewed because it has a range of inappropriate, vague and/or narrow associations. A distinction between convergent and generative thinking seems optimal, and I would distinguish between these different kinds of thinking in the following terms.

Table 1 Generative and Convergent Thinking

Productive thinking	Analytical or receptive thinking
Required by open questions	Required by closed questions
Having answers conditioned by views and values	Having one or a limited number of answers
Consonant with critical thinking	Consonant with problem solving
Entailing informal and plausible reasoning	Entailing formal and logico-deductive reasoning

It should be noted that the contrast between generative and convergent thinking does not imply a difference between higher and lower-order thinking. Both generative and convergent thinking are kinds of reasoning that contrast with lower-order recall of information.

What kind of thinking is being tested?

When one examines educational assessment in terms of generative thinking one finds a preponderance of closed questions requiring convergent thinking. In one sense this is not

¹ Guilford, J.P. (1967). *The Nature of Human Intelligence*. New York: McGraw-Hill.

surprising, as much of our effort to understand the world involves a search for certainty, but much of what we have to think about in real life (particularly in thinking about the socio-cultural and human world) is not a matter of objective truth. Much of the thinking we undertake in life involves reasoning about uncertain problems on which we will make arguable decisions. In normal life we are more commonly reviewing arguments for and against, and making decisions on the basis of arguable reasoning than we are analysing information to determine a correct answer or solve a problem.

The pressure to use closed questions to increase reliability at the expense of validity

There are pragmatic reasons why there is a preponderance of closed questions in educational assessments. There is a clear temptation of pose closed questions because they can be more or less unambiguously scored. But the pursuit of easy and reliable scoring can narrow the kind of thinking tested and compromise the validity of an assessment. Educational assessment should, in some measure, involve open questions that require generative thinking from students.

Testing generative thinking with open-ended tasks

In essence the multiple choice question format is inimical to generative thinking. I would argue that the closed multiple choice format can be use to test plausible rather than logico-deductive reasoning, but writing such items is very difficult, and few assessment agencies cultivate this art. Simply using the extended or short response formats (writing sample and short answer question) does not necessarily qualify as generative thinking. Some short answer questions are as closed as any multiple choice, and they can be, if well written, unambiguously scored. Some writing tasks require very constrained and convergent thinking of candidates. Subject content essays are commonly scored with a checklist of required 'points'. The Writing Sample of the Medical College Admission Test (MCAT), for instance, constrains the thinking of candidates within the following rigid restrictions.

Write a unified essay in which you perform the following tasks. Explain what you think the above statement means. Describe a specific situation in which a politician should take into account the beliefs of constituents when voting. Discuss what you think determines whether politicians should vote according to their beliefs or those of their constituents.

Such a writing test significantly reduces the cognitive challenge (and opportunity) involved in producing impromptu writing. Such writing tests (and they are common) seem to want to limit the generative thinking of a writing assessment, presumably in the pursuit of reliability of scoring. Such a writing test does not allow the kind of generative or open-ended thinking that one might expect in such tasks. And in my terms, a SAQ that can be more or less unambiguously scored is not a test of generative thinking.

The AST Test

In the following discussion I will review the attempts of my co-workers and me to ask open questions that require generative thinking in a system wide test called the ACT Scaling Test (AST). The AST is a cross-curricular test taken by students at the end of secondary school who aspire to tertiary courses. It is used to adjust the assessments of different colleges to make them comparable by placing scores on a common scale. The AST is a battery of three tests. There is a MCQ test of 80 items taken in 150 minute, a SAQ test of about 20 questions to be taken in 90 minutes, and a single writing task to be taken in 150 minutes. The AST specification describes the test as 'designed to measure, in the main, the abilities of comprehension, interpretation and reasoning, across as many curriculum areas as possible, with a level of conceptualisation and difficulty appropriate to the final year of secondary schooling'. It further defines the content of the test in terms of subject or curriculum area, stimulus material and skills or abilities. The test battery evolved over the

last 40 years. The MCQ component was developed in the 1970s, the writing test was developed in the 1980s, and the SAQ was first administered in 2004.

The AST Writing Test of generative thinking

The AST W is an unusual (perhaps a unique?) writing test. It is an assessment of verbal reasoning and writing ability in which candidates are requested to respond in an argumentative mode to a broad range of stimulus material on a social and/or political issue (see Appendix 1). AST W papers are an A3 sheet of newspaper articles, quotations from other texts and a cartoon on a broad theme. AST W was designed in the mid 1980s by ACER writing assessment specialists (in consultation with teachers) to be an authentic and hence valid test of the 'writing process'. AST W is a 'process writing test' in that candidates have 150 minutes to write 600 words and they are directed to write a draft and a finished copy of the piece in the time available. Only the finished draft is collected and assessed. Candidates are given the following instructions in the AST W.

Read carefully the material on these two pages.
Write an essay of about 600 words, giving your point of view on a major issue raised in the material.
Give your essay a clear title.
You should assume you are writing to an intelligent adult audience.

The stimulus on the paper offers a range of material with a more or less common theme. It is described by those who develop it as a 'questionless question' in that there is no specific issue offered for discussion. Quite different aspects of the stimulus can be selected for discussion by individual candidates, and they can develop a piece of writing in quite different ways. As a 'questionless question', the AST Writing Test is a challenge to generative thinking for candidates in that they have to select and define an issue for themselves. This characteristic of the task contrasts with the essay tests which emphasise answering a specific question, and use 'relevance' as a key criterion for assessment. (There is also a clear contrast with the MCAT writing test mentioned above.) The stimulus material offered for the AST Writing Test gives candidates a good deal of scope for constructing their own response to the broad theme. The 'questionless question' challenges candidates to identify and define an issue, and to construct a point of view about that issue.

Generative rather than convergent short answer questions

In developing the SAQ component of the AST in 2003 our test developers set out to pose questions that were quite different from those posed in the MCQ. We didn't want SAQ to be MCQ without the options. We expected that most SAQ would entail significant degrees of judgement by markers, and we intended to double mark most questions. In designing the SAQ test we wanted to use some open questions that require were not a matter of working out and supplying the correct answer. We wanted to ask open SAQ that would:

- be broad and general rather than specific;
- challenge candidates to identify issues and find problems;
- be open in that there need not be a correct answer;
- involve analysing and critiquing as well as information processing; and
- involve opinions and the development of arguments.

An Aligned and Teachable SAQ Test

The AST Writing Test had been designed to reflect good teaching practice. It was thought that colleges in the ACT could 'teach the test' in a meaningful and useful way. Similarly we wanted to develop an SAQ tests that would reflect good teaching and learning and be meaningfully and usefully teachable. We were hoping to pose fundamental questions that would reflect the sort of questions teachers might pose in teaching their subject, or to find archetypal questions that would be meaningful in a range of subjects and for a range of different topics.

This approach to the SAQ contrasts with our approach to MCQ. The best MCQ are written by posing unique rather than formulaic questions about rich stimulus. Like the MCQ in the battery, the SAQ would be stimulus based, but we aimed to write archetypal (or formulaic) rather than unique questions for the SAQ. We wanted the SAQ to focus consistently on some more or less specific skills, and allow teachers to find their own stimulus material and use the archetypal questions as a basis for developing understanding of a subject while also teaching more general skills. The AST SAQ test aims to develop a group of archetypal questions. They would be general questions that would be repeated from one form of the test to another. The questions (and the skills tested) would be familiar to teachers and students. Candidates would be expected to answer a familiar question about unfamiliar material.

A Cross-curricular SAQ Test

The AST MCQ is used as two sub-tests Humanities, Arts and Social Sciences (HASS) and Mathematics, Science and Technology (MST). The SAQ test is not envisaged as HASS and MST sub-tests, but as a cross-curricular whole. Nonetheless we did consider the kind of domain-related model of thinking shown in Table 1 in developing the SAQ items. This model is domain-related in that it presumes that what you ask questions about (domain, topic or content) has as much of more impact on the way candidates perform as what you ask them to do (process, task or skill). We considered ways of thinking about the human and the material worlds.

In our experience the tendencies and textures to questions about the human and the material worlds, and the different tendencies can be described as in table 3.

Table 3 Thinking about the human and the material worlds

Thinking about the human world?	Thinking about the material world?
Comprehend and interpret this written text, this concept, this image, this diagram and this data.	Comprehend this information and interpret this data
Evaluate this argument and produce an argument or counter argument	Deduce or apply these rules and calculate Critically analyse and hypothesise Evaluate an argument or conclusion

As table 3 suggests, you can ask the same question about quite different kinds of material, and the experience will be quite different for candidates.

Table 4 shows the kind of archetypal questions we are aiming for in the SAQ test.

Questions like these seem fundamental to schooling, and as we refine our model, we hope that teachers will see the kinds of questions asked in the SAQ test are (or can be) used by them in teaching their subjects. While these questions can be applied to all kinds of material, it is likely that the first three (Comprehension, Interpretation and Critical thinking) reflect learning in the humanities, arts and social sciences, and the second three (Data analysis, Problem solving and Systems analysis) more commonly reflect learning in the mathematics, science and technology.

Some examples of the AST SAQ are offered in Appendix 2. These SAQ aim to be broad, general and open questions that elicit generative thinking from candidates. The interpretive nature of examples 1 and 2 evidently require generative thinking. The material in example 3 could lend itself to convergent questions, but candidates are given a very general invitation to see what is significant in the data and offer an interpretation of it. Example 4 is a fairly conventional set of questions that ask candidates to describe and explain a trend in numerical data. It also moves towards critical thinking by asking candidates to offer a reason for and a reason against adding iodine to bread. Example 5 begins with a two convergent questions, but the third question is open and doesn't have a specific answer. These SAQ are not MCQ without the alternatives. They are open questions that require generative thinking of candidates to construct a response. As a result they ask candidates to think in ways that differs from the kind of thinking involved in responding to MCQ. Our

SAQ aim to relate to what teachers can or might do in the classroom. We believe that the use of archetypal questions allows teachers to address the skills tested in the SAQ which teaching their own subject area content.

Table 4 Some Archetypal Questions

Comprehension	What are the key ideas here? How do these ideas relate to each other?
Interpretation	How would you interpret this? What impressions are we given? What is suggested or implied? What does this add up to?
Critical thinking	What argument can support or rebut this? What do you make of this argument?
Data analysis	How would you interpret this data? What is significant in this data? What can be concluded from this data?
Problem solving	What is the problem? How can you solve this problem?
Systems analysis	Why is this so? How does this work?

Table 2 A Domain and Process-related Model of Thinking

<p align="center">Understanding scientific and technological concepts</p> <p align="center">Why is this like this? Why does this happen? How does this relate to that?</p>			<p align="center">Understanding Socio-cultural concepts</p> <p align="center">Why is this like this? Why does this happen? How does this relate to that?</p>		
<p>Understanding scientific & technological concepts</p> <p>Why is this like this?</p> <p>Why does this happen?</p> <p>How does this relate to that?</p>	<p>Solving Problems</p> <p>How does/should this work?</p> <p>What is the problem?</p> <p>What is the solution or possible solutions?</p>	<p>Dealing with information</p> <p>What does this data reveal?</p> <p>What hypothesis or conclusion does this data suggest?</p> <p>How strong or convincing is this data?</p>	<p>Thinking critically</p> <p>What view presented?</p> <p>How is this view supported?</p> <p>How strong or convincing is this view?</p>	<p>Interpreting meanings</p> <p>How is this presented?</p> <p>What does this suggest?</p> <p>What is your view of this?</p>	<p>Understanding Socio-cultural concepts</p> <p>Why is this like this?</p> <p>Why does this happen?</p> <p>How does this relate to that?</p>

Appendix 1 The AST Writing Test

Society has Regressed into a Coarse Battleground for the Graceless and Self-centred

We live in a culture where the primacy of the self and its satisfactions is everything. We are bombarded with messages telling us that we should have what we want because we're worth it. As consumers, we are kings. We know that we have rights, that brands seek our favour; that as long as we can pay, we feel powerful. We like that sensation. It is seductive because it is so at odds with the reality of the rest of our lives. As workers and producers we are under more pressure and feel more insecure than ever before. Our private lives are increasingly unpredictable, our financial futures uncertain. There is no general respect for mundane lives, well lived, in a popular culture that celebrates wealth, beauty, celebrity, notoriety and youth.

Jenni Russell

A Triumph of Cooperation

It is sometimes said selfishness is the basic motivation that shapes the behaviour of people.

'Look after number one.'
'Me and mine.'
'Dog eat dog.'

In fact our society is a triumph of cooperation. Our government is a great cooperative effort. We have law and order. We produce and exchange goods and services with each other. And for no payment people work for charities, coach sporting teams, and are volunteers in all kinds of socially valuable activities.

Charity Begins at Home

It's all very well to give to various charities, to volunteer our time to help others, and to forgo our own self-interest and look outwards to the needy within our community.

However it can be argued that society is best served if we look after the needs of our immediate family first. We shouldn't be made to feel guilty if we don't conspicuously donate our time and money to others beyond our family circle.

It seems logical to look after our own responsibilities first; then, only when we have met these responsibilities, should we look to expending our time, energy and money on others.

A Peace Corp Subject?

All students at Macquarie University will have to undertake volunteer work and study subjects from the arts and sciences under a plan designed to provide a broader education and more socially aware graduates.

In a first for an Australian university, Macquarie University vice-chancellor Steven Schwartz today will announce a partnership with Australia Volunteers International that will create a mini peace corps, giving undergraduate students the opportunity to do volunteer work overseas.

Called the Global Futures Program, it will develop activities with local communities throughout Australia, the South Pacific and Southeast Asia. Some form of community work will be compulsory for all undergraduate students at Macquarie under the new curriculum to start in 2010.

Read carefully the material on these two pages.

Write an essay of about 600 words, giving your point of view on a major issue raised in the material.

You need not refer to any of the material specifically, but you must deal with a major issue in it.

Do not summarise the material.

Give your essay a clear title.

You should assume you are writing to an intelligent adult audience.



Both Self-interest and a Fair Go

Recent research by a group of economists, anthropologists, biologists, psychologists and sociologists suggests that people are not simply selfish, materialistic creatures. It seems that they can behave generously and altruistically as long as others are doing so as well. People will also apply sanctions to those who behave unfairly according to the prevailing standards of cooperation.

The Selfish Gene

All creatures are selfish because their genes are designed to replicate themselves.

Volunteering – It's never too late!

Encouraging volunteering at all ages



"Since we all have to believe in something, I thought, 'Why not money?'"

Appendix 2 Some AST SAQ

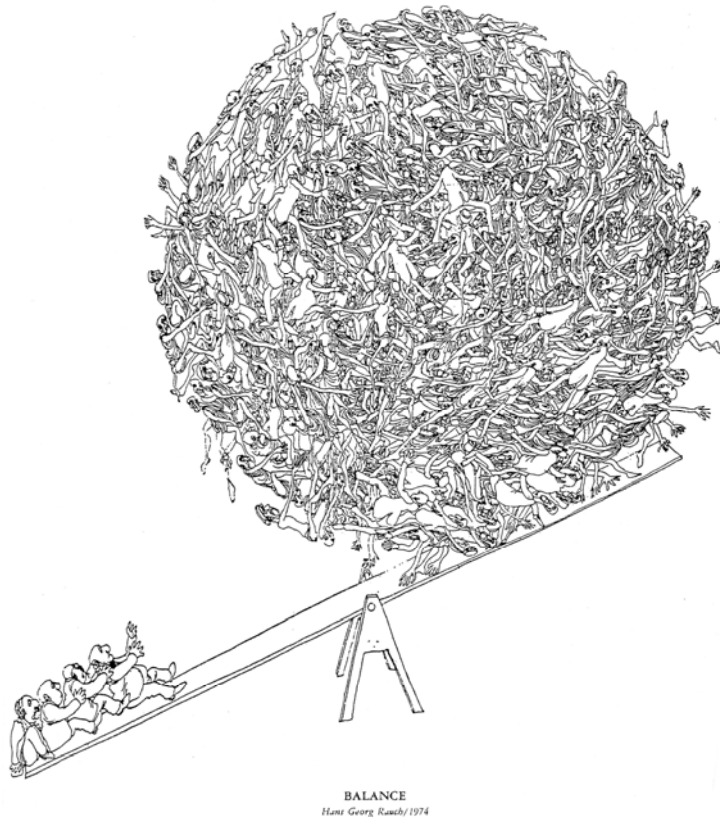
Example 1 Rauch's Balance

What impressions are we given by the drawing on the opposite page?
And what is suggested by the drawing?

Your responses will be judged on the:

- accuracy of the description and understanding of the material; and
- substance and quality of the interpretation offered

(4)



Example 2 Red Bull advertisement

There is an advertisement for a drink called Red Bull on the opposite page. What is suggested by the text and image?

How do the text and the image attempt to influence the viewer?

Your responses will be judged on the:

- accuracy of the description and understanding of the material; and
- substance and quality of the explanation offered.

IMPROVES PERFORMANCE

INCREASES ENDURANCE

INCREASES CONCENTRATION

IMPROVES REACTION SPEED

CURBS ANTISOCIAL BEHAVIOR

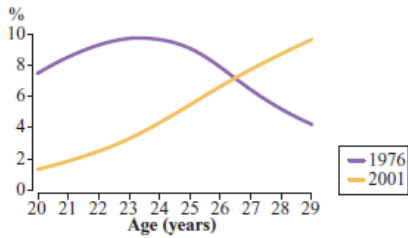
Red Bull does everything it says on the can. And nothing it doesn't.

RED BULL GIVES YOU WIIINGS.

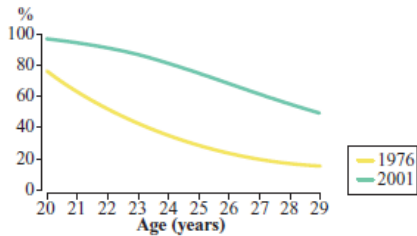
Example 3 Interpreting data about the 20 to 29 years age group in Australia

Compare and contrast the following graphs and the table about the 20 to 29 years age group in Australia.

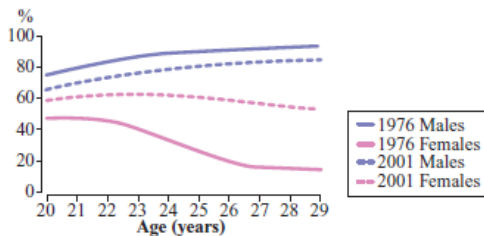
What are the main points suggested by a comparison of the graphs? (4)
Your comments will be judged on the accuracy, selectivity and significance of the interpretation you make of the graphs.



Graph 1
First births: Age of mother



Graph 2
Persons aged 20-29 years: Proportion never married



Example 4 Adding iodine to bread

Iodine is a nutrient that is needed in small amounts for good health. Lack of iodine in the diet can cause brain damage to unborn children, reduced mental performance and slow development in children and adolescents. Too much iodine in the diet following a period of too little iodine can have negative effects on some individuals.

A proposal to add iodine to bread was opened for public comment. The following table contains information from this proposal.

Estimated average requirement (EAR) is an estimate of the average requirement for a nutrient of a group of people. About 50% of the group will need less than the EAR and about 50% will need more than the EAR.

Dietary intake is the amount of iodine in the food eaten by a person.

Table 1 Estimated Percentage for Australian and New Zealand Population Groups Consuming Less than the EAR for Iodine

Country	Population group	EAR $\mu\text{g/day}$	Percentage of Respondents with Dietary Intakes of Iodine < EAR (%)
Australia	2-3 years	65	43
	4-8 years	65	41
	9-13 years	80	45
	14-18 years	100	52
	19 years and above	100	65
New Zealand	15-18 years	100	64
	19 years and above	100	65

Question 1

Describe the trends in dietary intake of iodine in Australia and New Zealand.

Question 2

Give two reasons that could explain the trend or the trends in Australia.

Question 3

Use the information in Table 1 and the text, to provide one reason for adding iodine to bread and bread products, and one reason against adding iodine to bread and bread products.

Example 5 Presenting mobile phone data

The table shows the number of mobile phones per 100 people in five countries in a particular year.

Country	Number of mobile phones per 100 people
A	65
B	75
C	35
D	25
E	80

Three students present the data in three different ways (Figures 1, 2 and 3).

- Note the background grids in Figures 2 and 3 are drawn to the same scale.

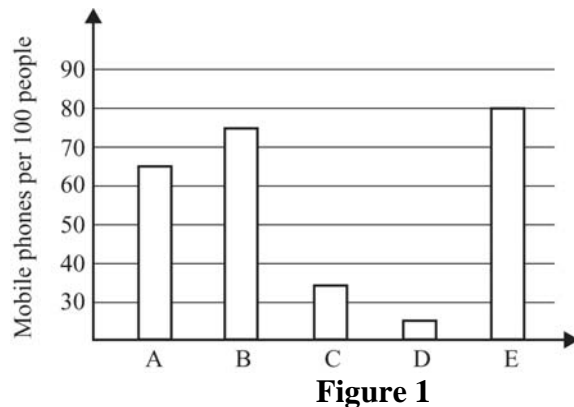


Figure 1

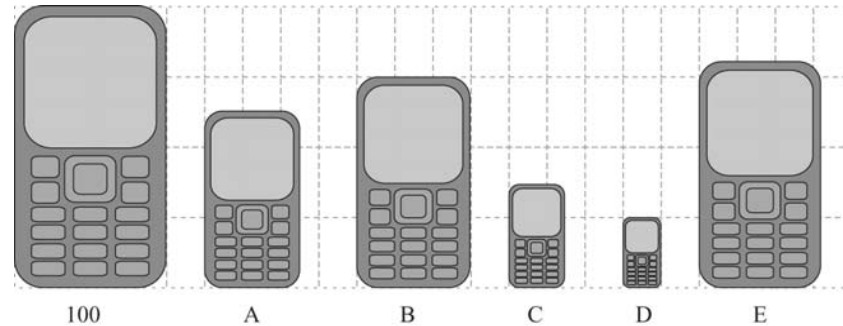


Figure 2

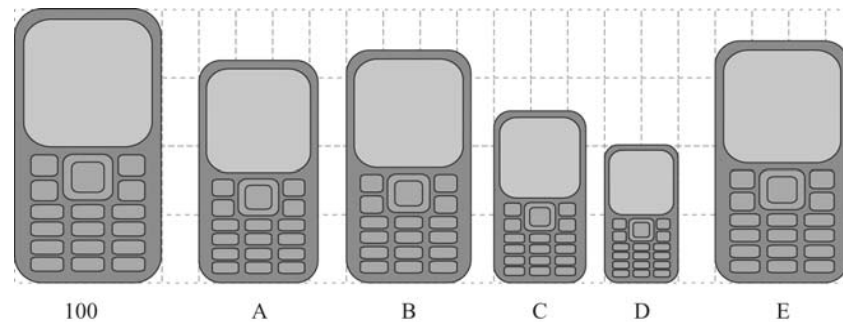


Figure 3

Question 1

What does the information in the table show about the number of mobile phones in these countries? (1)

Question 2

Why might the graph in Figure 1 be misleading? (1)

Question 3

Compare and contrast the representations of the table data in Figures 1, 2 and 3. (3)