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Working memory, performance and learner characteristics

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A range of characteristics of learners is described and their relationship to working memory discussed in the context of teaching and learning in the sciences. The characteristics are extent of field dependency, visual spatial abilities, divergency and convergency. These learner characteristics were measured for a large sample of school pupils aged about 13 along with the working memory capacity of the pupils. The relationships between all these measures are discussed and also related to performance in science in national examinations. Most of the work is set in Kuwait, with some data from Saudi Arabia. It is found that working memory capacity correlates highly significantly with all the learner characteristics and this is interpreted in terms of the way information is processed in the brain. Some implications for learning in the sciences are discussed.

Keywords: learner characteristics; working memory; examination performance

Introduction

Teele (2000, 70) remarked 'When our students are given the opportunity to let their light shine, they reveal a full prism of colours or abilities that may never be discovered if they are not allowed to use their full spectrum of intelligences'. Humans are incredibly diverse in their abilities and any attempt to reduce measurement of human abilities to a single number is, in the present state of knowledge, unlikely to be successful, even within a single subject discipline. This paper seeks to consider a small portion of this diversity, centering on the concept of working memory, and looking at how various learner characteristics relate to academic performance and working memory capacity. The work is set in two Middle Eastern countries but the findings are not restricted to any educational system.

Learner characteristics

Coles and Robinson (1989) argue for more emphasis on the kind of teaching where attention is paid to the more detailed ways by which children learn. Johnstone (1993, 703) notes that information processing models suggest the presence of 'mechanisms in the learning process'. Indeed, while all learning requires the processing of information, the detailed variations in the way information is processed and stored are important (Leyden 1990). This paper seeks to explore some of the variations and interpret the findings in terms of the way information is processed, especially the role of working memory.

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Different authors have used different terminology to describe this diversity of learning behaviour, with phrases like cognitive style, learning style, cognitive characteristic and learning strategy all being used. In this paper, the phrase 'learner characteristic' will be employed as a general term to cover all aspects of the different variations in learning approaches. Witkin (1978, 39) described such approaches as a 'characteristic mode of functioning that we reveal throughout our perceptual and intellectual activities in a highly consistent and pervasive way'. In fact, numerous other definitions exist (see Messick et al. 1976, 5; Ehrman and Leaver 2003, 311; Riding and Pearson 1995, 413; Tennant 1997, 80; Riding and Rayner 1998, 8). Usama (2002) notes that cognitive characteristics relate to the way in which people tend to perceive, remember, think, solve problems, organise and represent information in their minds. This offers a useful picture.

McKenna (1984) suggests that the key distinction between characteristics and ability is found in the ideas of *level* and *manner*. Abilities tend to focus on *levels of performance*, emphasising minimum performance and final outcomes, while characteristics consider the *manner of performance*, with the emphasis on the processes involved in completing a task. A fundamental aspect of learner characteristics lies in their origin and this can be considered as three questions. Are learner characteristics:

(a) Essentially fixed (genetic)?
(b) Open to learning (formally or by life experiences)?
(c) Mainly matters of choice?

Of course, a specific learner characteristic may involve more than one of these and, perhaps, involve all three?

Some learner characteristics

Field dependency

Witkin's (1949) concept of field dependence/field independence attracted great interest and motivated much research (see Witkin 1962, cited in Govier and Govier 1992; Vernon 1972; Goodenough 1976; Witkin and Goodenough 1977, 1981; Witkin et al. 1977; Witkin 1978; Govier and Govier 1992; Saracho 1997; Paramo and Tinajero 1997; Dawyer and Moore 2001) since it appears to provide an objectively measurable dimension of cognition which has important implications for the way students learn.

Field dependency is considered to be a bipolar expression of individual differences (Witkin 1978). Witkin describes as field dependent an individual who has difficulty in separating an item from its context. An individual who can easily break up an organised field and separate relevant material from its context or discern signal (what matters) from noise (the incidental and peripheral) in a confusing background is field independent (Johnstone and Al-Naeme 1991).

Many researchers (see Wayss 2002; Ramirez and Castaneda 1974; Saracho 1997), have offered descriptions of the characteristics of those who are field dependent and those who are field independent and Esmaeel (2001) has summarised these. In the context of science education (or, indeed, all education), the key feature is the extent to which the person can select what is important for a task in hand, leaving aside what is not important for that task. The Johnstone analogy of selecting the 'message' from the 'noise' is apt.

In various studies in relation to the sciences and to mathematics, a relationship between the extent of field dependency and the working memory capacity is usually found (see El-Banna 1987; Al-Naeme 1988; Danili 2001; Christou 2001) and this is often seen in terms of the field independent student being able to select better and thus not overload the working memory.

Convergency–divergency

Hudson (1966) developed the idea of convergency–divergency. In simple terms, the more divergent person could move from one idea to relate it to many other ideas while the more convergent person tended to bring ideas together to some kind of conclusion. Hudson never saw this characteristic as fixed, arguing (1968, 91) that:

> No one was, or was ever expected to be consistently convergent or consistently divergent. I have never seen why someone should not drift slowly over a period of years from divergence to convergence, or vice versa. Nor why someone should not be divergent in some moods and convergent in others. Nor why someone might not be convergent (or divergent).

Several studies have explored the relationships of convergency/divergency to performance in tests and examinations (see Getzels and Jackson 1962; Hudson 1966; Wallach and Kogan 1965) while Hudson himself related the characteristic to abilities in arts and science subjects. Kolb and Fry (1975) have summarised the supposed characteristics of convergent and divergent thinkers. Atherton (2004) argues that convergency is appropriate in science, mathematics and technology but evidence suggests that being divergent is almost always an advantage in examinations in these subject areas (Danili and Reid 2006). However, the test used in the study of divergency is essentially a test of divergency, a low mark often being assumed to indicate convergency. Danili and Reid were careful only to refer to divergency.

Convergent thinking means that someone has to focus on, or converge on, the one idea or answer in order to find the solution to a problem. Convergent thinkers score highly in problems requiring one conventionally accepted solution clearly obtainable from the information available while at the same time obtaining low scores in problems requiring the generation of several equally acceptable solutions.

In many tests and examinations in the sciences, rewards come from the correct recall or recognition of information, perhaps favouring those who are convergent (Hudson 1966). However, Danili and Reid (2006) showed that those who were divergent did best in chemistry. This might be explained in terms of the types of questions being asked and, indeed, this study looked at different test formats and did find variations in the extent to which the divergent held an advantage. Nonetheless, in every test format in every topic, those who were divergent scored as well or better.

The test of divergency (Bahar et al. 1999) essentially measures the ability to perform well in open-ended tasks, to generate ideas and see things from different perspectives, and be strong in imaginative ability. It is assumed that a low mark indicates convergency.

Visual–spatial ability

Although the visual–spatial has recently assumed greater importance over the years, with the advent of television and computer technologies, early work by Silverman (1989) laid the foundation for educational interest, a good description being supplied by Silverman (2003) who refers to those who think in pictures rather than in words. Kerr (1991) has listed the skills where the visual–spatially able excel while many have offered lists of visual–spatial characteristics (Jonassen and Grabowski 1993; Silverman 1989; Golon 2004; Codd 2006). Grandin (1996) has a vivid description:

> Words are like a second language to me. I translate both spoken and written words into full-color movies, complete with sound, which run like a VCR tape in my head. When somebody speaks to me, his words are instantly translated into a picture.

Various studies (Silverman 1989) found high proportions of such learners at school levels. Silverman (2002) observes that visual–spatial thinkers learn better visually when compared to the auditory route. They tend not to learn from repetition and drill and they tend to see things as whole pictures before they learn the details. Of great importance is that learning does not take place step by step and an instruction like 'show your work' may prove an impossible request.

The implications for the sciences of the visual–spatial characteristic are immense, with the extensive use of diagrams, graphs, models and visual representations: circuit diagrams and geometrical optics in physics, the various visual representations of electrolysis and diagrams to show atomic and molecular structures in chemistry, models of biological structures and various life cycles in biology.

Working memory

This is not usually regarded as a learner characteristic but it varies from individual to individual and grows with age up to about age 16 (Miller 1956). Numerous studies have shown that working memory capacity is genetically fixed from about age 16 and is closely correlated with academic performance (see Gathecole et al. 2006). Working memory can be conceptualised as a thinking–holding space. It can be seen as that part of the brain where incoming information is placed temporarily. It is where thinking, interpreting, understanding and problem-solving takes place. It has a fixed capacity and this makes it a control on learning (Johnstone 1997).

Thus, working memory can be conceptualised as a psychological space of limited capacity. Measures of its capacity can be based simply on measuring how much can be held at one time (for example a list of numbers). It is found, with adults, that the capacity is 7 ± 2. Any processing will leave less space for holding information. Thus, for example, Johnstone and Selepeng (2001) found a reduction in measured capacity when working in a second language while the digit span forwards test (measuring holding) gives a higher result than the digit span backwards test (which involves holding and inverting the order of the numbers) (Mancy 2007).

It is worth noting that the various early tests of working memory capacity often tended to be verbal in style (see Sperling 1960; Klemner 1963; Philips 1974) but Pascual-Leone (1970) developed a visual test which is now widely used. In one study, El-Banna (1987) (see also Johnstone and El-Banna 1986, 1989) used both the figural intersection test of Pascual-Leone and the verbal–numerical digit-span backwards test of Miller (1956), with the results for the vast majority being the same for both tests.

Baddeley (1986) found evidence showing that the working memory had some kind of separate 'loops' for visual material and auditory–verbal material while those with higher abilities in the visual–spatial were found to be better at recalling (Hitch et al. 1989; Snodgrass et al. 1972).

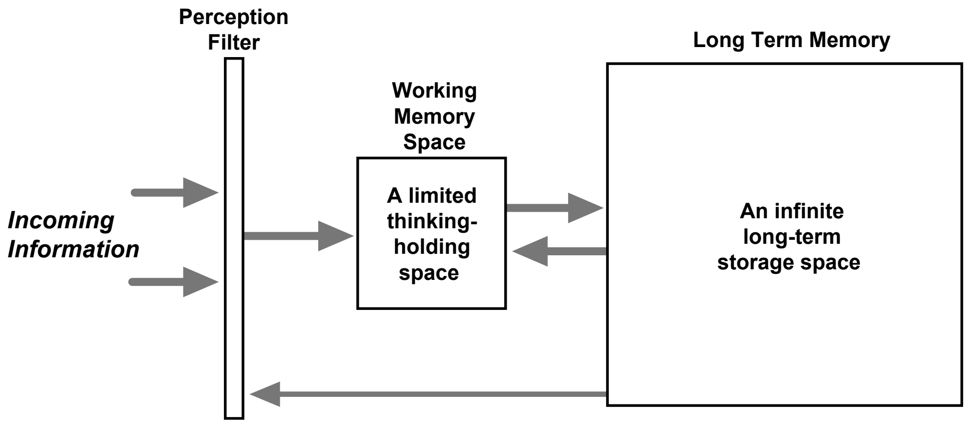

Figure 1. Information processing.

Those with higher working memory capacities tend to perform best in many examinations and tests (see Johnstone 1991, 1997; Danili and Reid 2004; Reid 2008). Reid (2002) noted that this relationship is known to be a function of the type of testing most commonly used and, if test items are designed appropriately, working memory capacity does not relate to performance. An under-explored area is the speed of processing and it is perfectly possible that those who process information faster in their working memories may also perform better while it is well known that those who can 'chunk' better will perform better (Miller 1956).

The central role of working memory as a rate determining feature of learning (seen as understanding) is now well established (see Johnstone 1997). In this, the working memory receives information from a perception filter and is able to interact with the long-term memory (Figure 1).

The important question explored in this paper is how this model might interpret what is known about learner characteristics. Specifically, what evidence is there that the working memory has a possible role in such characteristics?

Experimental

Several measurements were made on 641 students, aged 13, drawn from schools in Kuwait. This was part of a larger study, involving six school disciplines, which looked particularly at those students who were well above average. Although the sample contained students of all abilities, it, therefore, contained higher proportions of the more able when compared to the typical population at this age. Although marks were gained, and standardised, in national examinations for six school subjects, the emphasis here will be mainly on science marks, working memory capacity and learners' characteristics.

The working memory capacities of the students were measured using the figural intersection test (Pascual-Leone 1970) while the extent of field dependency was measured using the group embedded figure test (Witkin et al. 1974). Extent of divergency was measured using a test based used by Bahar et al. (1999) while a new test of visual–spatial abilities was developed. The test of visual–spatial abilities was based on six skills: discrimination between different forms and shapes, the counting of shapes with different sizes and positions, distinguishing between figures and their backgrounds and inverse images, estimations of distances and velocities, accurate perception of shapes and number of shapes, speed tracking information visually

The test was computer driven with moving shapes, diagrams and pictures being used, colour and movement being important. Typically, the students were shown a picture or diagram and had to answer a question relating to what they saw. There were 48 items and the test was timed. The test went through numerous trials with experienced teachers and a large sample of students of age 13 before it reached its final form. Scores ranged from 3 to 33, mean 17.3 and standard deviation 5.2.

The outcomes from all these measurements were correlated. First of all, the measurements of the three learner characteristics and working memory capacity were correlated using Pearson correlation, with performance in the six school subjects, the correlations with the science marks being shown in Table 1. All the measurements formed good approximations to normal distributions.

All the correlation coefficients were significant at $p < 0.001$. This means that pupils at this age in Kuwait tended to perform better in the science examination if they had a high working memory, were field independent, were divergent and showed strong visual–spatial characteristics. The divergent effect was by far the largest. The questions then arise: is science being measured or is the science examination a test of a range of cognitive characteristics? Or, is being good at science to be equated, at least in part, with higher levels of skills in these characteristics?

Factor analysis on the data on working memory capacity and the six subjects was carried out using principal components analysis with varimax rotation. Two factors were found, the factor loadings being shown in Table 2.

The six subjects all loaded on to one factor (Component 1). A study of the examination papers involved shows that this has to be recall. The measurement of working memory by the figural intersection test involved holding and manipulating mentally various shapes in working memory. This is a very different skill when compared to

Table 1. Working memory, learner characteristics and performance.

$N = 641$	Science marks
Working memory	0.23
Field dependency	0.19
Divergency	0.54
Visual–spatial	0.33

Table 2. Factor loadings.

	Components	
	1	2
Working memory capacity	0.11	0.99
Social studies	0.93	0.00
Islamic studies	0.92	0.00
Mathematics	0.92	0.12
Science	0.95	0.13
English	0.92	0.00
Arabic	0.93	0.10

recall from long-term memory and the measurement loads onto the second factor almost perfectly. The sad observation is that the science examination is essentially a test of recall, most of the questions being fill-in or multiple-choice testing recognition of memorised answers. For example, the students were simply asked to record a word, state a relationship or offer a fixed factual answer to a question – things like: the colour of copper sulphate is…, the name of the force which hinders motion is…, the part of a cell which controls cell function is the…, etc.

The outcomes from the tests of the three learner characteristics can also be correlated to working memory capacity (Table 3).

Of course, these correlation values do not necessarily imply that working memory capacity controls these learner characteristics in some way. However, it is interesting to suggest some possible interpretations of the data. Field dependency relates to the ability to select information efficiently for a task. It is well established that field dependency correlates positively with working memory capacity, the field independent characteristic being seen as one aspect of the efficiency by which working memory operates (Johnstone and Al-Naeme 1991). Thus, if working memory involves an economy of information, then this leaves more space for processing. This may well be achieved by the perception filter working efficiently and this is controlled by the way the long-term memory operates in information storage.

Being divergent means being able to use (or generate) links between ideas in long-term memory. It has been established that divergency correlates with academic performance in chemistry (Danili and Reid 2006) and, particulary, open-ended problem-solving ability in biology (Al-Qasmi 2006). In the latter study, it was suggested that this was dependent on the presence of usable, accessible links between ideas in long-term memory. Thus, perhaps, the student with the larger working memory capacity has an advantage in generating more links when ideas are stored in long-term memory and this is reflected in a positive correlation with outcomes from a test of divergency (which might be seen as a measure of the usable links in long-term memory).

Being visually–spatially able means a strong tendency to see things in terms of pictures, diagrams or spatial relationships and these must be stored in long-term memory. There is the possibility that this learner characteristic relates in some way to the visual loop in working memory (Baddeley 1986). Does the person with a more developed visual loop show a higher working memory capacity? Or is it simply that the student with the higher working memory capacity can see things more completely and, therefore, storing information in terms of pictures, diagrams or spatial relationships becomes a stronger possibility?

A correlation of 0.39 ($p < 0.001$) was found for extent of divergency related to visual–spatial ability. If extent of divergency is a measure of usable links in long-term memory, then it is possible that those who, for some reason, can store information in long-term memory in the form of pictures, diagrams or spatial relationships will tend

Table 3. Correlations with working memory capacity.

	Working memory capacity
Field dependency	0.30
Divergency	0.22
Visual–spatial	0.21

to be more divergent simply because pictures, diagrams or spatial relationships imply links between ideas.

However, it is possible that being convergent is a quite separate characteristic. Thus, a student could be either divergent or convergent, or neither, or both. This picks up Hudson's early speculation (1968). To explore this possibility, a test of convergency was needed. A list of the characteristics of a convergent student was compiled and a test devised to measure some of these characteristics (see Table 4).

The development of a test of convergency proved difficult. It is relatively easy to show the ability to generate ideas (divergency). It is much more difficult to show how the student can bring ideas together. Nonetheless, a test was devised and set in a format which exactly paralleled the divergency test. After much editing following careful scrutiny by many teachers and researchers, it was trialled with a small group of 13-year-old students in Arabic before being used with a larger sample. The trialling involved discussion with the students after they had completed the test to explore why they had responded in the way they did. The test is shown in the Appendix.

The new test of convergency was used with a group of 754 students along with the established test of divergency. The student marks in science were also obtained as before and correlated with scores in the three learner characteristics (Table 5).

This suggests that being *both* divergent *and* convergent is an advantage in school national examinations in science in Kuwait. These examinations test recall and many of the questions are in objective test format or are questions requiring very short factual answers. The measurements from the convergency test and the divergency test correlate with each other ($r = 0.51$, $p < 0.001$) and both correlate with the visual–spatial test (divergency: $r = 0.33$, $p < 0.001$; convergency: $r = 0.41$, $p < 0.001$). The question is how can this be interpreted in terms of the way the human brain handles information and, specifically, related to working memory.

Because the convergency–divergency results were unexpected, a further study used the same tests for convergency and divergency with three age groups in Saudi

Table 4. Convergent test description.

Section	Description	Aim
1	Classify countries and their capitals according to two ways	Finding relationships
	Gives letter in a random order, the student is required to form words	Put in right order and understanding sequencing using words
	Consider number sequences to look for and describe pattern	Understand sequencing using numbers. Seeing patterns and drawing a conclusion
2	Read and then summarise a paragraph to show three main ideas and then relate these	Picking out key ideas and leaving aside and seeing relationships
3	Given four sets of pictures, student is required to see which does not fit and why	Finding the relationship; pattern seeking
4	Given four graphs, students are required to spot common features	Ability to identify common features presented in graphical form
5	Describe an itinerary (given a map) so that someone can follow the route	Extract from a matrix of information the key essential features, giving a coherent logical order

Table 5. Correlations with science marks.

$N = 754$	Science
Convergency	0.50
Divergency	0.41
Visual–spatial	0.27

Table 6. Convergency and divergency correlations.

	Age	Convergency	Divergency
Divergency	12	0.45	
	13	0.60	
	14	0.65	
Mathematics score	12	0.43	0.40
	13	0.36	0.47
	14	0.61	0.59

Arabia, this time in relation to mathematics, the samples being drawn randomly from the population. The outcomes show the same general pattern (Table 6) for the sample of 574.

Thus, the pupil who is both divergent and convergent does best in examinations. While being visual–spatial may lead to more usable links in long-term memory and hence divergency, the presence of these links may allow the more convergent to find their way (in their long-term memory) to the required answer. However, this may have implications for the working memory. Here information is handled and prepared for storage in long-term memory. Is there something about the way the working memory operates which enables some students to create more usable links (perhaps by storing more visually)? It is possible that the visual loop in the working memory has a critical role to play in this?

Discussion

Working memory capacity correlates positively and significantly with the outcomes from an established test of divergency, an established test of field dependency and a new test of visual–spatial abilities. Those who are divergent also tend to be those who are convergent, assuming the validity of the new convergent test.

Thus, ability in science can be seen as being related to the working memory capacity and the work of El-Banna and Johnstone (1986, 1989) shows clearly that this is cause and effect. Where the test materials are exploring more than the recall of science information, the correlation coefficients become higher, the highest one seen being 0.62 for genetics at school level (Chu 2008).

Overall, the surprising finding in the work described here is the way working memory capacity relates to a range of learner characteristics. This might imply that having a larger working memory not only gives the learner an advantage in learning and assessment tasks but having a larger working memory holds considerable advantage in relation to three learner characteristics. Each of these can be considered in turn. Figure 1 is the backcloth against which the discussion is set.

(a) *Field dependency.* Being field independent means that the person is more efficient in selecting what is important and relevant for a particular task or situation: selecting independently from a field of information (Witkin 1962, cited in Govier and Govier 1992). This suggests that, in some way, the perception filter is working more efficiently and effectively (Johnstone 1997). However, this is controlled by what is held in long-term memory. These suggest that the way the information is stored in long-term memory enables a person to select better. This could be because of brain structure or it could be because of the way the working memory has influenced the way information is stored. Being field independent always brings better test performance in chemistry (Danili and Reid 2006).

If a student is field independent, then the working memory is less likely to become overloaded with information irrelevant to the task in hand (Johnstone and Al-Naeme 1991). This is the most likely explanation of the correlation between the two variables. It might be argued that the figural intersection test and group embedded test are both tests based on geometrical shapes and thus might be expected to correlate positively. However, measurements from the digit-span backwards test and the group embedded test also correlate positively (Christou 2001).

(b) *Convergency–divergency.* The learner who is divergent is able to access more effectively more links between ideas in long-term memory (Al-Qasmi 2006). How and why this happens is uncertain. It could be because the working memory stores new information in the long-term memory in such a way that many links are formed. It could simply be based on genetics – some people are born with a better brain architecture. It could even be a matter of choice: some people choose to link ideas more than others. Of course, it might be a combination of any two or all three. Being divergent always seems to be advantageous in tests in chemistry (Danili and Reid 2006).

The results for the convergency test are more difficult to explain. It is possible to see convergency as the absence of divergency but convergency is a positive learning characteristic in its own right (Hudson 1968). The convergent is able to bring things together to make a useful coherent whole, or give a meaningful conclusion. In some way, the working memory is able to pull together information from many parts of the long-term memory in order to reach this endpoint. There is an ability to analyse, think logically and deductively. This implies an ability relentlessly to pursue links in long-term memory to reach an answer, draw a conclusion or make a deduction. Having a larger working memory capacity may enable the student to pursue several links in long-term memory making recall easier.

In the context of the sciences, both being convergent and being divergent may have major advantages. Those who are good at the sciences (and other subjects) need to be good divergers to look for links and patterns and see how things relate to each other. Equally, after that, ideas need to be brought together to draw conclusions and see a clear pattern. The results here show that performance is related to characteristics of divergency and characteristics of convergence and this might offer an explanation.

(c) *Visual–spatial ability*. It has been shown that the working memory has two loops (one a visual–spatial sketchpad, the other an auditory loop) (Baddeley 1986). It is possible that the more visual–spatial learner possesses a better developed working memory loop for the visual–spatial. Equally, it is possible that the way information is stored gives a preference for information stored in the visual–spatial way. In an interesting experiment some years ago, it was found that presenting questions in visual form helped some students, the symbolic form helped others (but not as many) while presenting in both forms gave the best overall results (Johnstone 1993). This could be explained by the use of both working memory loops or it could be explained by the idea that storing information in two forms gives the greatest advantage. It could simply be that, if information is stored in multiple ways, there are more links and, therefore, a better chance of reaching a desired piece of information.

In looking at these three learner characteristics, it is clear that they can be interpreted in many ways, involving all three parts of the human memory. Fundamentally, convergency–divergency seems to relate primarily to storage, field dependency is focused on the way the perception filter is controlled while visual spatial ability could be explain by the working memory or storage preferences.

A number of other issues arise. To what extent, if at all, can these abilities be enhanced by teaching, training or experience? Do they develop with age? Finally, to what extent do they reflect personal choice: does a learner build on some innate characteristic because they find it offers a more congenial way to learn? It seems possible, and perhaps likely, that the answers to these questions will be positive. However, the real issue for this study is to speculate on the way the information model (Figure 1) can help to interpret these learning characteristics.

The positive correlations with measured working memory capacity offer some useful insights. If the learned material is stored in a way where there are more links between ideas, this might explain the correlations with extent of divergency and visual spatial abilities. This makes some sense in that the larger working memory capacity allows more ideas to be held at the same time, thus making it more likely that links between ideas can be generated.

In biology, chemistry and physics, the linking together of ideas to give a meaningful whole is vitally important in making sense of many conceptual areas. Thus, working memory capacity not only has a direct influence on the learning process but perhaps it also allows the formation of more coherent understandings of concepts, this being reflected in measurements of relationships between working memory capacity and other learner characteristics.

Final thoughts

Learner characteristics have featured widely in the literature of education. It is very difficult to reduce the enormous variability in learner characteristics to a manageable size and this study has focussed only on four well-known characteristics and on working memory capacity. The relationships between these characteristics and working memory capacity in terms of correlation poses some fascinating questions in terms of how the characteristics can be explained in the context of the working memory, the long-term memory and the perception filter.

Baddeley (2002) has reviewed the multi-component structure of working memory and this may have particular relevance in the way different learners show strengths in various learner characteristics. It is hoped that the study outlined here will stimulate interest in pursuing this further in order to offer a more certain interpretation of the considerable variability in the way learners learn best as seen in the outcomes of examinations and tests.

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Appendix. Convergency test

Test 1

(1) Look at the table below:

Morocco	Iran	Oman	Qatar	Lebanon
Rabat	Karachi	Beirut	Masqat	Doha
Egypt	Pakistan	France	United Kingdom	Spain
Cairo	Teheran	Madrid	Paris	London

There are many patterns in the table which could link the names in the table together. Find two patterns and write them down.

Pattern 1……………………………….………………………..………………………..……
Pattern 2………………………………………..………………………..………………….

(2) Put the letters in the right order to give a correct word.

- E O N T ………………………………………..
- R E N I D F ………………………………………..
- E A C P E ………………………………………..

(3) Here are several sets of numbers. Add the next number in each sequence for each, and then explain why you chose the number.

- 2 …. 4 …. 8 …. □

Explain:………………………………………..………………………………………

- 1 …. 3 …. 6 …. 10 …. 15 …. □

Explain:………………………………………..………….....……..……………………

One mark was given for each correct answer, giving a maximum of seven marks. The students are given five minutes and then, together, they move on to Test 2.

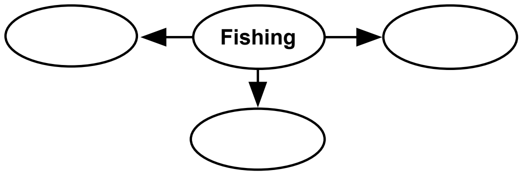
Test 2

Here is a short piece of writing, pick out the three main ideas. Place the three main ideas in the diagram below.

I like to eat fish

Kuwait can trace its traditions back to fishermen, the pearl divers and the merchant mariners. Before the discovery of oil, with the abundance of fish along Kuwait's coastline, Kuwait's fishing industry was the main source of both food and income. Historically, fishing was concentrated within five miles of the shore since small vessels were unable to go into the deeper waters. Although the traditional fishing equipment was simple, relying on the use of stake traps and wire traps, most of it is still used by fishermen today with a little modernization. Today traditional methods still yield an impressive harvest of fish.

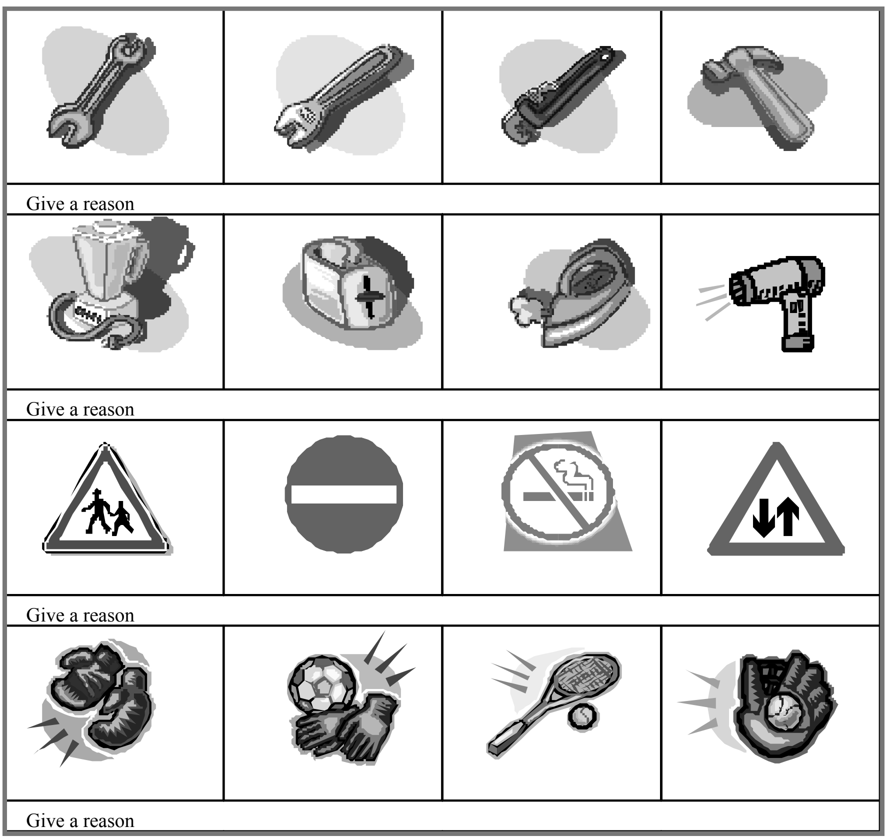
Annually Kuwait catches over 8000 tons of fish (including 2200 tons of shrimp). Kuwait has long been conscious of preserving its second natural resource. The Agriculture and Fisheries Department at the Kuwait Institute for Scientific Research (KISR) has one of the most comprehensive programmes in the Middle Ease for the artificial breeding of fish, specifically *Zubaidy* and *Hamour*. In May 1997, KISR embarked on a five year experiment that would require transporting fertilized eggs from the sea to be hatched and raised among KISR's facilities and eventually released back into the sea.



This test is given five minutes and the student is given one mark for every correct idea with a maximum of three marks.

Test 3

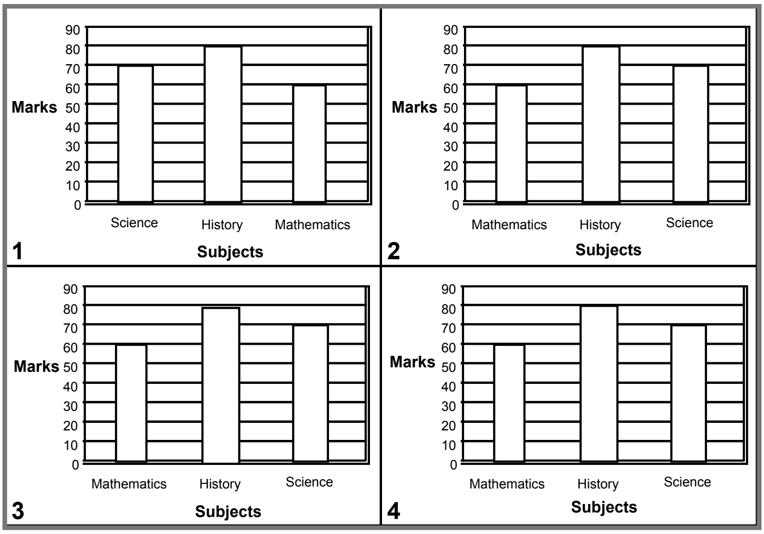
Look at each line. Pick out the object which is different in some way and put a cross against it. Then give a reason why you selected it.



Eight marks given for test three: one mark for each choice and one mark for each correct acceptable reason.
This test needs three minutes to complete.

Test 4

Here are four graphs showing how students performed in examinations. All have the same axes, labelled in the same way. Look at the four graphs carefully. Write down two things which are **true for all four** graphs.



There are two marks allocated, one for each correct answer (there are, in fact, more than two things).

Test 5

There is a man standing near the school (on the map start point). Help him to go to a nursery then to the supermarket (the end point) by drawing the way on the map.

Use a pen or pencil and mark the route clearly on the map

Write a description of the way you drew the map.

The student was given a coloured map as shown above.

Five minutes were allowed for this part and a maximum of four marks were awarded.