Master thesis

Exploring the relation between visual and verbal learning styles, and performance on abstract and concrete problem solving tasks.

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Abstract

The aim of this study is to check whether there is a difference in how well verbal and visual learners solve concrete and abstract problems. It is hypothesized that the more verbal learners are better at solving abstract tasks and the more visual learners are better at solving concrete tasks. The participants were 28 college and university educated people from the Netherlands. All participants filled out the revised VVQ by Kirby, Moore and Schofield (1988) and took three tests. Analysis showed that verbal learners did score a bit better on the abstract task, though results were not significant.

Keywords:abstract, concrete, VVQ, visual, verbal, problem solving

Introduction

The assumption that different persons have different learning styles is broadly acknowledged. One of these assumptions is that some people are better in processing words and others have a preference for visual information (see Kolloffel, 2012; and Mayer & Massa, 2003). This thought led to the idea that adapting the content of instructional materials to the learning style of the learner can lead to improved learning outcomes. Developments in ICT based instruction and in datamining techniques have created new possibilities to adapt the learning materials to characteristics of the learners (Hung, Chang & Lin, 2016). However the scientific status of learning styles theories is open for discussion (Coffield, Moseley, Hall & Ecclestone, 2004; and Willingham, Hughes & Dobolyi, 2015). Willingham, Hughes and Dobolyi (2015) recently stated that scientific support for these theories is lacking. On the other hand, Hung, Chang and Lin (2016) concluded that there is a relationship between various types of learning style clusters and learning performance in game-based problem-solving activities. "Learners with visual, reflective and intuitive abilities demonstrated significantly higher problem-solving performance" (Hung, Chang & Lin, 2016, page 560). Problem solving is an important cognitive ability which is one of the main skills associated with 21st century learning (see Rotherham & Willingham, 2010). This was the main reason for this study to explore the relationship between visual and verbal learning styles, and performance on abstract and concrete problem solving tasks.

Learning styles

To cite Mayer & Massa (2003): "Some people are better at processing words and some people are better at processing pictures. This statement [...] can be called the *visualizer-verbalizer hypothesis*" (p. 833). To truly understand the differences between these two groups, it is necessary to conceptualize and measure the visual-verbal dimension. Mayer & Massa (2003)

therefore tested whether this dimension can be decomposed into three different facets: cognitive ability, cognitive style, and learning preference. Cognitive ability refers to things that people are able to do (possessing low or high spatial ability) , cognitive style refers to the ways that people process and represent information (thinking with words (verbalizer) or images (visualizer)), and learning preferences refer to the ways that people like information to be presented to them (preferring instruction with text (verbal learner) or graphics (visual learner)). They found that the visual-verbal dimension can be decomposed in these three facets.

In 1977, Richardson devised a questionnaire to test whether people are more of a visual or a verbal learner (test their learning preference). This questionnaire is called the Verbalizer-Visualizer Questionnaire or "VVQ" in short. The VVQ consists of 15 true-false questions and scores on a single bipolar dimension, such that subjects with a high score tend to be more visual learners and subjects with a low score tend to be more verbal learners.

Therefore, they conducted a study where they had 119 students fill out the VVQ as Richardson devised it in 1977 and take tests to measure their verbal and visual ability. First off Kirby, Moore and Schofield (1988) analyzed results with a one-factor solution, as suggested by Richardson. This analysis showed that two items related to visual issues (and do not involve dreams or imagination) had very low loadings. They also found out that the one factor does not discriminate between verbal and visual approaches. This lead to the conclusion that a single factor solution is not acceptable. Therefore, they analyzed results with a two- and three-factor solution. The three-factor solution seemed to account for all items, but only by splitting the visual factor in two: dream vividness (regarding dreams and imagination) and visual preference (regarding visual issues). However, one factor consisted of just two items, which made it inadequate.

These findings suggest that the validity of the VVQ is quite low. Therefore Kirby, Moore and Schofield (1988) decided to devise a new questionnaire where there would be a distinct verbal, visual and dream vividness factors.

Their new questionnaire consisted of 30 items: 10 verbal items, 10 visual items and 10 dream items. They tested whether the items could be loaded on the factor they were intended for, which seemed to be true. The factors were almost exclusively defined by the items designed to do so. Also, the verbal factor related more to verbal than visual ability, the visual factor related more to visualization and the dream scale to nothing in particular. This last finding suggests that the dream scale will not likely be useful as a predictor of learning.

In 2012 the revised VVQ was used by Kollöffel to test the relationship between cognitive style preference and actual performance. He therefore used 48 participants and divided them into two groups: visual or verbal instruction condition. Before participants executed the learning task, they had to fill out some tests. One of them was an extended version of the VVQ (where the tests regarding verbal style, visual style and dream vividness were used). Participants also had to take tests on object visualization (recognize what is depicted), spatial visualization (indicate direction to an object from a certain viewpoint), verbal ability and knowledge. After that participants were introduced to the learning task, where one group received a visual - and the other group a verbal instruction. The group that received visual instruction had higher post-test scores. No correlations were found between cognitive style preferences and cognitive abilities (what they are actually good at), and learning outcomes. It did turn out that verbal ability is a moderately strong predictor for learning outcome, and that spatial ability did not contribute whatsoever.

Though it seemed that preferences do not make much of a difference, it must be said that individual differences do play a role. When the right representational format is picked, it can

optimize the learning opportunities for most students. How much they can actually benefit from it is partially determined by their cognitive abilities (Kollöffel, 2012).

Something that seems to be in line with above results is that, in contrary to what one would think, the performance of visualizers on spatial ability tests is not superior to that of verbalizers (Lean & Clements, 1981). Similarly, clinical psychologists have not (yet) found a relation between a person's preferences to process information visually and their scores on imagery vividness questionnaires (see Hiscock, 1978, for a review).

There also seem to be two types of visualisation: visual imagery and spatial imagery. Visual imagery is the representation of the appearance of an object (like shape, size, color, or brightness). Spatial imagery is the representation of the spatial relations between parts of an object, the location of objects in space and their movements, and does not solely rely on sight (you could also have an auditory or tactile spatial image). Kozhevnikov, Hegarty and Mayer (2002) suggest that the difference between visual and spatial imagery also exists in individual differences in how we see things. Some people may construct concrete, detailed images of objects (visual imagery), others may create abstract images that represent the spatial relations between objects (spatial imagery). The 'visual imagers' are called iconic types and the 'spatial imagers' are called the spatial type.

To test their theory, Kozhevnikov et al. (2002) conducted two studies. Their first study tested whether there really are two kinds of visualizers. It existed of 60 participants, who had to fill in a pretest, execute two spatial relations tests, two spatial visualization tests, a verbal ability test and a VVQ test. The results showed that visualizers are not a homogeneous group, but exist of two different groups: visualizers of high and visualizers of low spatial ability (visualizers of average level seemed to be verbalizers). It also showed that the majority of verbalizers and visualizers have average verbal ability. The second study tested whether high and low spatial

visualizers generate different types of mental images. There were 17 participants who took the same test tests as in the first study, but in addition the materials had two kinematics ("motion") problems. It turned out that the two types of visualizers interpret motion graphs differently. The visualizers with low spatial ability (iconic types) generate concrete images and see graphs as showing a concrete situation that would match the shape of the graph. Visualizers with high spatial ability (spatial types) generate mostly schematic images and see graphs as an abstract representation.

So it seems there is also a difference between whether people rather learn with concrete or abstract materials. Concrete materials relate to prior knowledge, are grounded in perceptual and/or motor experiences, and have a lot of similarities between what they look like and what they are supposed to represent (Fyfe, E. R., McNeil, N. M., Son, J. Y., & Goldstone, R. L., 2014). Fyfe et al. (2014) uses different articles to highlight the benefits of using concrete materials. They state four of them: (1) concrete materials supply a context that makes sure real-world knowledge is activated during learning (Schliemann & Carraher, 2002); (2) concrete materials encourage physical or imagined action, which can improve memory and understanding (Glenberg, Gutierrez, Levin, Japuntich, & Kaschak, 2004); (3) concrete materials invite learners to build their own knowledge of abstract concepts (Brown, McNeil, & Glenberg, 2009); and (4) concrete materials make use of brain regions connected to perceptual processing, and approximately 25-40% of the human cortex is being used for visual information processing (Evans-Martin, 2005).b Nonetheless, using concrete materials do have some disadvantages. For example: they contain a lot of extraneous (useless) details, which can distract from the useful information and therefore make transfer harder for (young) learners who cannot control their attentional focus that well (Kaminski, Sloutsky, & Heckler, 2008).

Abstract materials on the other hand, do not have extraneous details, but do represent the structure of the object efficiently, and can be used as a template in a broader sense (Fyfe, E. R., McNeil, N. M., Son, J. Y., & Goldstone, R. L., 2014). They also are easier to generalize (Kaminski, Sloutsky, & Heckler, 2009; Son, Smith, & Goldstone, 2008). However, abstract materials can lead to inefficient solution strategies (Koedinger & Nathan, 2004), rigid use of learned procedures (McNeil & Alibali, 2005), and illogical errors (Carraher & Schliemann, 1985; Stigler, Givyin, & Thompson, 2010). In general, using abstract materials can cause learners to not truly understand what they are doing (Nathan, 2012).

But which is better: concrete or abstract? According to Klee & Eysenck (1973) concrete material is easier to learn and retain than abstract material. An explanation for this is a theory of Paivio (1969), which states that concrete material works with a non-verbal imaginal code and a verbal symbolic code, and abstract material only works with the verbal symbolic code. This is also known as a dual-coding model. In 1971 Paivio & Begg extended this theory. They hypothesized that comprehension of abstract sentences mostly relied on verbal associative reactions and intraverbal context, and comprehension of concrete sentences relied on nonverbal imagery. Their experiments supported this hypothesis.

Klee & Eysenk (1973) decided to conduct experiments to check whether the dual-coding theory bare some kind of truth. They found that comprehension of isolated concrete sentences seemed to rely more on imaginal coding, whereas abstract sentences seemed to rely more on verbal processes. Comparing this to Kozhevnikov et al. (2012), where iconic types generate concrete images and spatial types generate abstract images, it seems that comprehending abstract sentences and images rely on the same processes.

Considering all this, it seems there can be made a difference between concrete and abstract learners, and visual and verbal learners. However, according to the introduction, it can be possible to match these four types of learners. This study will attempt to do so.

Hypotheses

This study will try to explore whether the adapted version of the VVQ by Kirby, Moore and Schofield (1988) could predict whether one scores better on visual or verbal tasks. Furthermore the relation between visual and verbal learners, and performance on concrete and abstract tasks was explored. This was done by giving the subjects Kirby, Moore and Schofield's (1988) version of the VVQ and letting them solve two (concrete) problem solving tasks, of which one was more verbal and one more visual, and one abstract task.

Three hypotheses were formed: (1) The subjects who score higher on the verbal scale, will do better at solving the verbal task. Therefore, the subjects who score higher on the visual scale, will do better at solving the visual task. (2) The subjects who score higher on the verbal scale, will do better at solving the abstract tasks. (3) The dream scale will not be useful as a predictor of performance on these tasks. Kirby, Moore and Schofield (1988) hypothesised that this scale may be more related to non-cognitive tasks.

Method

Participants

Twenty-eight college and university educated people of different colleges and universities in the Netherlands participated in this study. Age ranged between 19 and 62, with M_{age} = 24,71 years; 39,3% males and 60,7% university students.

Materials

The Verbalizer-Visualizer Questionnaire (VVQ) developed by Kirby, Moore and Schofield in 1988 (see Appendix 1) was used to assess the learning style. The questions were randomized. The test was handed out on paper and filled in with pen. For each of the three scales (verbal, visual and dream) there was a maximum of 10 points.

I find illustrations or diagrams help me when I'm reading.	Yes / No
I dislike looking words up in dictionairies.	Yes / No

Figure 1. Example of an item from the VVQ.

Three tests were used to assess problem solving abilities. All of the tests that were used were existing tests. This was done because it means that these tests were already, in some way, standardized. The McKinsey test was selected as the verbal test, the PISA as the visual test and the Abstract test to check abstract comprehension.

The two concrete problem solving tasks both consisted of ten questions. The first test was the more visual test and part of the PISA Problem Solving Test of 2003. The second test was the more verbal test and part of the McKinsey Problem Solving Test of 2013. Both tests were handed

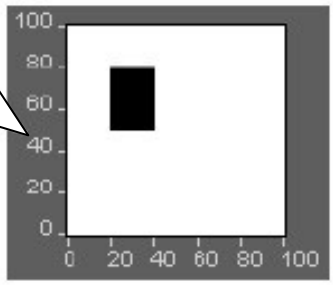
out on paper and filled in with pen. The PISA Problem solving test was edited so the answers wouldn't be directly visible (see Appendix 2). The original of the McKinsey Problem Solving test was used (see Appendix 3). The maximum score for both tests was 10 points.

Question 3: DESIGN BY NUMBERS

Question intent: System Analysis and Design

The following shows an example of the "Repeat" command.

```
Paper 0
Pen 100
Repeat A 50 80
{
  Line 20 A 40 A
}
```



The command "Repeat A 50 80" tells the program to repeat the actions in brackets { }, for successive values of A from A=50 to A=80.

Write commands to generate the following graphic:

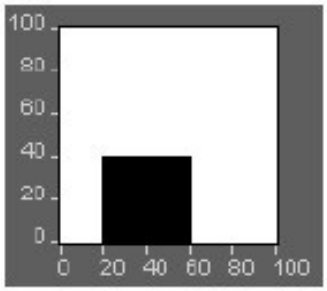


Figure 2. Example of a problem from the PISA test.

In preparing further for the *G8* meeting, the team decides that it would be a good idea to use some specific examples of recent major innovations to help better explain the importance of Innovation Capital.

A team member suggests using Apple's *iPod* music player as such an example. The team readily agrees to this suggestion. They believe that the development of the *iPod* not only illustrates all three types of Innovation Capital, but it also shows how up-front investment in Innovation Capital can lead to follow-on advantages for the investor that accumulate over time.

9. Which of the following statements LEAST illustrates the Innovation Capital underlying the development of Apple's *iPod*?
    A. New software and technology was required to allow the distribution of music through online channels
    B. New pricing was negotiated with the music industry to encourage online music purchasing
    C. New design concepts were developed that gave the product an appealing look and feel
    D. A new way of working with the music industry was developed to allow rapid distribution of new music to *iPod* users

Figure 3. Example of a problem from the McKinsey test.

The abstract task consisted of 15 questions. The test used was the Inductive Reasoning, Free Sample Test 2 by AssessmentDay. This test was edited, because the original had some distracting logos on every page (see Appendix 4). The maximum score for this test was 15 points.

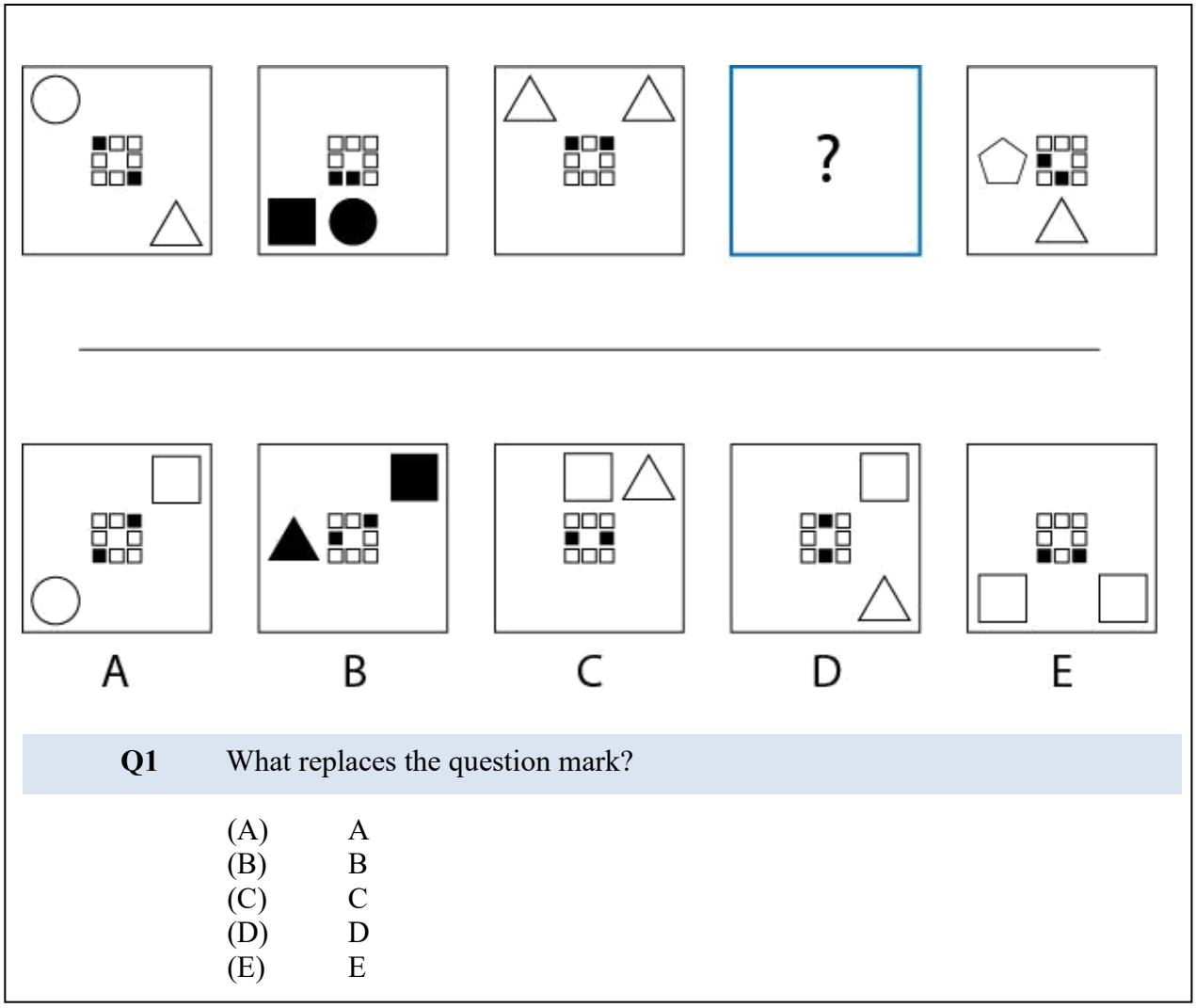


Figure 4. Example of a problem from the Abstract Test.

Procedure

The procedure was equal for every participant. They were given a short introduction to inform them about what they had to do and give them the purpose of this study. When everything was clear, they could start by reading the informed consent,. After the informed consent, participants had to answer three demographic questions about sex, age and education. After this, the actual test started. Participants were given an hour and a half to finish everything. Although most

participants needed this time, some were done within the hour. All participants finished in time. Participants were allowed to highlight, make notes, write on the paper as much as they needed.

Each version of the test started with the VVQ as revised by Kirby, Moore and Schofield (1988). The two problem solving tasks and the abstract tasks were randomized. There were six different sequences: (1) Abstract, McKinsey, Pisa; (2) McKinsey, Pisa, Abstract; (3) Pisa, Abstract, McKinsey; (4) Pisa, McKinsey, Abstract; (5) McKinsey, Abstract, Pisa; (6) Abstract, Pisa, McKinsey.

Results

Overall mean scores

The overall mean scores are listed in the Table 1. Since the highest scores on the VVQ for all scales is ten, everything below five is considered low and everything above is considered high. It can be seen that the respondents score high on the visual scale of the VVQ ,just above the median on the verbal scale and rather high on the dream scale.The standard deviations indicate that there is a large spread in the score on the dream scale.

Furthermore the score on the PISA problem solving test is high, the score on the McKinsey test is rather low and the score on the Abstract test is high.The standard deviations indicate that there is a large spread in the score on the Abstract problem solving test.

Table 1. *Overall mean scores and standard deviations for the three scales of the VVQ and the three problem solving tasks. Maximum score is 10, except for the abstract task for which it is 15.*

	M	SD
Verbal scale	6.04	1.73
Visual scale	8.21	1.37
Dream scale	7.18	2.74
PISA (visual)	8.46	1.29
McKinsey (verbal)	3.25	1.69
Abstract	8.86	2.59

Correlations between tests scores and the scores on the VVQ scales

The correlation between the different tests and the different scales are listed in Table 2. There were three significant scores found: the correlation between the Verbal scale and the Pisa test ($p = 0.03$), the correlation between the PISA test and the Abstract test ($p = 0.02$) and the correlation between the McKinsey test and the Abstract test ($p = 0.05$).

Table 2. *Correlations between VVQ scales scores and tests scores*

	Verbal	Visual	Dream	PISA	McKinsey	Abstract
Verbal						
Visual	0.28					
Dream	0.21	0.22				
PISA	0.37*	0.15	-0.02			
McKinsey	0.30	0.18	-0.20	0.13		
Abstract	0.13	-0.01	-0.13	0.39*	0.31*	

Differences on test scores between high and low scoring persons on the VVQ scales

In Tables 3 to 5 the differences on test scores between high and low scoring persons on the VVQ scales are presented. For these differences, the scores of the Visual, Verbal and Dream scales were divided into highs and lows: scores one to five are low, and six to ten are high. The results of the test scores, sorted by verbal scale are listed in Table 3. Ten participants scored low on the verbal scale, 18 scored high. A one-way ANOVA showed that only the differences on the McKinsey test were significant: $F(1, 26) = 4.43$, $p = 0.05$. The results on the ANOVA for the PISA test were: $F(1, 26) = 3.22$, $p > 0.05$. For the Abstract test they were: $F(1, 26) = 1.75$, $p > 0.05$.

Table 3. *Test scores for persons scoring high and low on the Verbal scale*

	Low		High	
	M	SD	M	SD
PISA	7.90	1.37	8.87	1.17
McKinsey	2.40*	1.07*	3.72*	1.81*
Abstract	8.00	3.02	9.33	2.28

The results of the test scores, sorted by verbal scale are listed in Table 4. One participant scored low on the visual scale, 27 scored high. The low scoring group has no standard deviations, since it consisted of just one participant. A one-way ANOVA showed that none of these differences were significant (ANOVA results for the PISA test: $F(1, 26) = 0.13$, $p > 0.05$. For the McKinsey test: $(F1, 26) = 0.56$, $p > 0.05$. For the Abstract test: $F(1, 26) = 2.42$, $p > 0.05$).

Table 4. *Test scores for persons scoring high and low on the Visual scale*

	Low		High	
	M	SD	M	SD
PISA	8.00	-	8.48	1.31
McKinsey	2.00	-	3.30	1.71
Abstract	5.00	-	9.00	2.53

Note. No significant results. Low scoring group consists of just one participant.

The results of the test scores, sorted by dream scale are listed in Table 5. Seven participants scored low on the dream scale, 21 scored high. A one-way ANOVA showed that none of these differences were significant (ANOVA results for the PISA test: $F(1, 26) = 0.06$, $p > 0.05$. For the McKinsey test: $(F1, 26) = 2.77$, $p > 0.05$. For the Abstract test: $F(1, 26) = 0.44$, $p > 0.05$).

Table 5. *Test scores for persons scoring high and low on the Dream scale*

	Low		High	
	M	SD	M	SD
PISA	8.57	1.27	8.43	1.33
McKinsey	4.14	1.95	2.95	1.53
Abstract	9.43	2.70	8.67	2.59

Discussion

In the introduction three hypotheses were formulated: (1) The subjects who score higher on the verbal scale, will do better at solving the verbal task. Therefore, the subjects who score higher on the visual scale, will do better at solving the visual task. (2) The subjects who score higher on the verbal scale, will do better at solving the abstract tasks. (3) The dream scale will not be useful as a predictor of performance on these tasks.. Here, it will be attempted to answer these hypotheses.

When you look at the first set of results, where the group is split into two: low (1-5) and high (6-10) scoring; it is notable that both the group who scored high on the visual scale and the group who scored high on the verbal scale, score slightly higher than the overall average on the PISA Problem Solving Test.. The group who scored high on verbal did even better than the group who scored high on visual. This contradicts the second part of the first hypothesis where it is stated that the people who score higher on the visual scale, do better on the visual test (PISA problem solving test). Both high scoring groups also score slightly higher than average on the McKinsey Problem solving test. These results, however, were not significant . The group who scored high on the verbal scale did do better than the group who scored high on visual, and these scores were even significant. This is in line with the first part of the first hypothesis where it is stated that people who score higher on the verbal scale, do better on the verbal test. . It must also be noted that both low scoring groups did worse than the overall mean on all the tests. Taken together, the first hypotheses cannot be acknowledged, though thefirst part seems to be confirmed.

Now on to the second hypothesis: “The subjects who score higher on the verbal scale, will do better at solving the abstract tasks.”. Again, it seems both high scoring groups scored better than the overall mean on the Abstract task. Although none of the scores were significant, it is noticeable that the verbal group did do better than the visual group. This is in line with the

hypothesis. Both low scoring groups did worse than the mean score on the Abstract test. Again, none of these scores were significant. So it seems the second hypothesis cannot be confirmed.

The third hypothesis stated that the Dream scale would not be useful as a predictor of performance. Results show that the group who scored high on the Dream scale scored lower than the mean on all three tests. What is notable, however, is that the low-scoring group scored higher than the mean on all tests. On the McKinsey and Abstract test, these scores were even higher than those of the high scoring Verbal groups. Again, none of these results were significant. No significant results show that these results do not account for anything in particular, which means the third hypothesis can be confirmed.

It must also be said that all participants, but one scored high on multiple scales. This means they did not have one specific style. This could have interfered with their results on the concrete and abstract tests: if a participant seems to be a verbal as well as a visual learner, they have an advantage on both types of tests.

As for the tests chosen: the McKinsey test was selected as the verbal test, the PISA as the visual test and the Abstract test to check abstract comprehension. However, when the scales are correlated with the tests, it shows that the Verbal scale correlates slightly higher with the PISA test than it does with the McKinsey test (the correlation of the Verbal scale with the PISA test even is significant: $p = 0.03$). Also, the Visual scale correlates slightly higher with the McKinsey test than it does with the PISA test. One explanation for this is that both these tests are not (just) measuring what they were intended since the PISA was chosen for measuring visual ability and the McKinsey was chosen to measure verbal ability. It seems as though they are better suited to measure the scale they were not intended for. It must also be noted that both the PISA and McKinsey test correlate on a significant level with the Abstract test. This means that both the PISA and McKinsey test are somehow connected to the Abstract test. It would make sense for the

McKinsey test to be connected to the Abstract test, as both these tests were intended to make use of verbal ability in some way, though it seems a bit strange that the PISA test also relates to the Abstract test. Somehow, all tests seem to measure some underlying construct. This was not anticipated. Another explanation can be that the VVQ does not measure what it is supposed to measure.

Results show quite large differences between scores on the PISA and the McKinsey test, which could be explained by the difference between the tests in general. The PISA Problem Solving Test is developed for 15 year olds to test their problem solving skills, whereas the McKinsey test is developed by Mckinsey & Company to check whether someone would be qualified to work for them. This makes the PISA test more suitable for a younger audience and therefore possibly quite a bit easier. Besides the McKinsey being harder than the PISA, it also focuses more on reading comprehension and is more analytical. This can make the results a bit biased, as is probably what happened during this research.

It is also noticeable that the majority of the participants were visual learners, according to their results on the VVQ. This was also found by Pallapu (2007): “The results of this study yielded a statistically significant difference between the visual and verbal learners. The majority were visual learners which has implications in the classroom and learning environment” (p.37), and Felder & Silverman (1988) “Most people of collage age and older are visual” (p. 676).

Being a visual learner means that learning with diagrams, pictures, charts etc. is preferred. Therefore it could be considered adjusting classes or books to this type of learning, as it may help students to learn better and perhaps even faster. Though this still is under discussion. For example, Kollöffel’s research in 2012 showed that there were no correlations between cognitive style and either cognitive ability or learning performance, so a person’s preference is not linked to what they are good at. On the other hand, Felder & Silverman (1988) said that mismatches

between the way of learning and teaching can lead to, for example, bored students or poorly performances on tests. They also noted that most learning and teaching styles coincide with one another: “a student who favors visual perception would be most comfortable with an instructor who uses charts, pictures and films”(p.674).

If this research were to be repeated, it will be wise to use tests that are at the same level of difficulty, so the test results will be fairer. It also seems good to check the tests that will be used beforehand, for example with a pilot group, to see whether they measure what they are intended to measure.

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Appendix 1: VVQ by Kirby, Moore and Schofield (1988)

I enjoy learning new words.	Yes / No
My powers of imagination are higher than average.	Yes / No
I seldom daydream.	Yes / No
I don't believe that anyone can think in terms of mental pictures.	Yes / No
I can hardly ever remember my dreams.	Yes / No
I find illustrations or diagrams help me when I'm reading.	Yes / No
I dislike looking words up in dictionairies.	Yes / No
When I read books with maps in them, I refer to the maps a lot.	Yes / No
The old saying "A picture is worth a thousand words" is certainly true for me.	Yes / No
I have always disliked jigsaw puzzles.	Yes / No
I enjoy daydreaming.	Yes / No
I spend little time attempting to increase my vocabulary.	Yes / No
I seldom fantasize.	Yes / No
My dreams are extremely vivid.	Yes / No
I find maps helpful in finding my way around a new city.	Yes / No
I seldom dream.	Yes / No
I like newspaper articles that have graphs.	Yes / No
I prefer to read instructions about how to do something rather than have someone show me.	Yes / No

I dislike word games like crossword puzzles.	Yes / No
I enjoy doing work that requires the use of words.	Yes / No
My dreams are sometimes so vivid I feel as though I actually experience the scene.	Yes / No
I seldom use diagrams to explain things.	Yes / No
I don't like maps or diagrams in books.	Yes / No
I often dream about things I'd like to be.	Yes / No
I read rather slowly.	Yes / No
I have a hard time making a "mental picture" of a place that I've only been to a few times.	Yes / No
My dreams are rather indistinct and hazy.	Yes / No
I have better than average fluency in using words.	Yes / No
I can easily think of synonyms for words.	Yes / No
I have a hard time remembering the words to songs.	Yes / No

Appendix 2: PISA Problem Solving Test 2003

MOVIE OUTING

This problem is about finding a suitable time and date to go to a movie.

Isaac, a 15-year-old, wants to organize a movie outing with two of his friends, who are of the same age, during the one-week school vacation. The vacation begins on Saturday March 24th and ends on Sunday April 1st.

Isaac asks his friends for suitable dates and times for the outing. The following information is what he received.

Fred: *"I have to stay home on Monday and Wednesday afternoons for music practice between 2:30 and 3:30"*

Stanley: *"I've to visit grandmother on Sundays, so it can't be Sundays. I have seen Pokamin and don't want to see it again."*

Isaac's parents insist that he only goes to movies suitable for his age and does not walk home. They will pick up the boys any time up to 10 p.m.

Isaac checks the movie times for the vacation week. This is the information that he finds.

TIVOLI MOVIE THEATER

Advance Booking Number: 919-545-6400
24 hour phone number: 919-545-6405
Bargain Day Tuesdays: All films $5

Films showing from Fri March 23rd for two weeks:

Children in the Net		**Pokamin**	
113 mins 2:00 p.m. (Mon-Fri only) 9:35 p.m. (Sat/Sun only)	Suitable only for persons of 12 years and over	105 mins 1:40 p.m. (Daily) 4:35 p.m. (Daily)	Parental Guidance. General viewing, but some scenes may be unsuitable for young children
Monsters from the Deep		**Enigma**	
164 mins 7:55 p.m. (Fri/Sat only)	Suitable only for persons of 18 years and over	144 mins 3:00 p.m. (Mon-Fri only) 6:00 p.m. (Sat/Sun only)	Suitable only for persons of 12 years and over
Carnivore		**King of the Wild**	
148 mins 6:30 p.m. (Daily)	Suitable only for persons of 18 years and over	117 mins 2:35 p.m. (Mon-Fri only) 6:50 p.m.(Sat/Sun only)	Suitable for persons of all ages

Question 1: MOVIE OUTING

Question intent: Decision Making

Taking into account the information Isaac found on the movies, and the information he got from his friends, which of the six movies should Isaac and the boys consider watching?

Circle "Yes" or "No" for each movie.

Movie	**Should the three boys consider watching the movie?**
Children in the Net	Yes / No
Monsters from the Deep	Yes / No
Carnivore	Yes / No
Pokamin	Yes / No
Enigma	Yes / No
King of the Wild	Yes / No

Question 2: MOVIE OUTING

Question intent: Decision Making

If the three boys decided on going to "Children in the Net," which of the following dates is suitable for them?

A Monday, March 26th

B Wednesday, March 28th

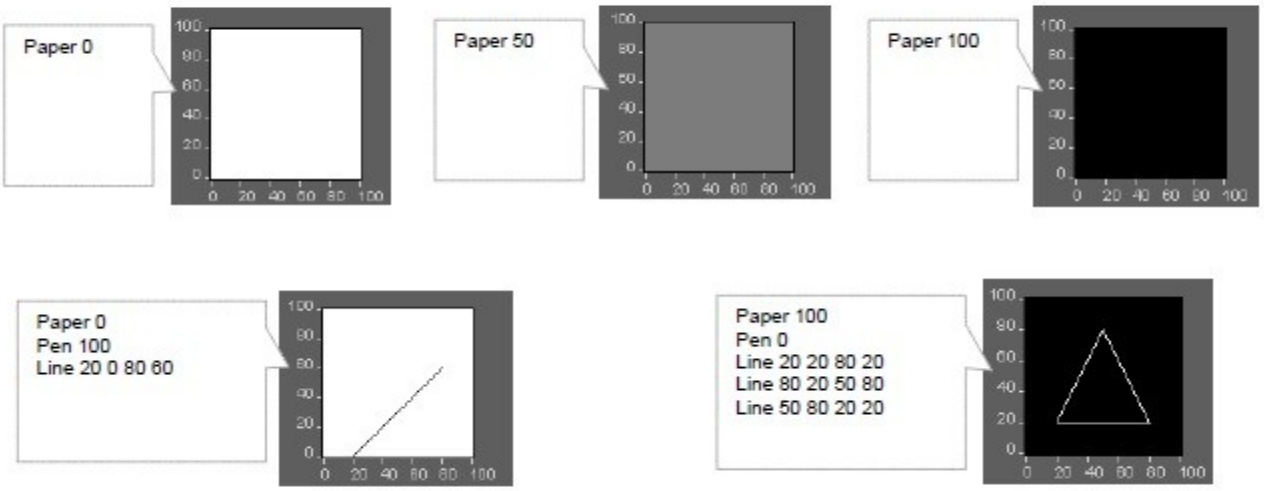
C Friday, March 30th

D Saturday, March 31st

DESIGN BY NUMBERS©

Design by Numbers is a design tool for generating graphics on computers. Pictures can be generated by giving a set of commands to the program.

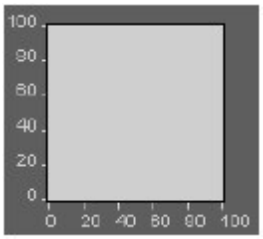
Study carefully the following example commands and pictures before answering the questions.



Question 1: DESIGN BY NUMBERS

Question intent: System Analysis and Design

Which of the following commands generated the graphic shown below?



A Paper 0

B Paper 20

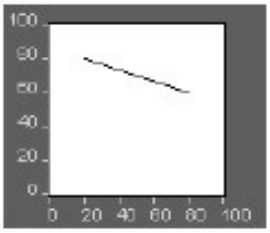
C Paper 50

D Paper 75

Question 2: DESIGN BY NUMBERS

Question intent: System Analysis and Design

Which of the following set of commands generated the graphic shown below?



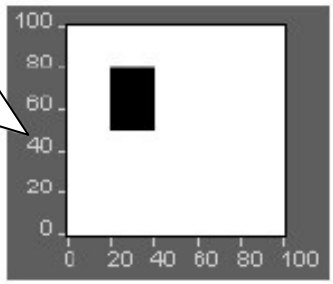
A	Paper 100	Pen 0	Line 80 20 80 60
B	Paper 0	Pen 100	Line 80 20 60 80
C	Paper 100	Pen 0	Line 20 80 80 60
D	Paper 0	Pen 100	Line 20 80 80 60

Question 3: DESIGN BY NUMBERS

Question intent: System Analysis and Design

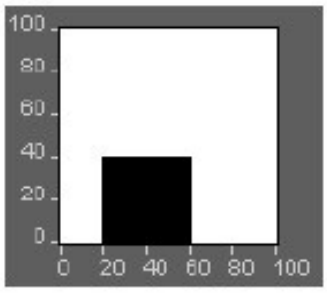
The following shows an example of the "Repeat" command.

```
Paper 0
Pen 100
Repeat A 50 80
{
  Line 20 A 40 A
}
```



The command "Repeat A 50 80" tells the program to repeat the actions in brackets { }, for successive values of A from A=50 to A=80.

Write commands to generate the following graphic:



TRIP

This problem is about planning the best route for a trip.

Figures 1 and 2 show a map of the area and the distances between towns.

Figure 1: Map of roads between towns.

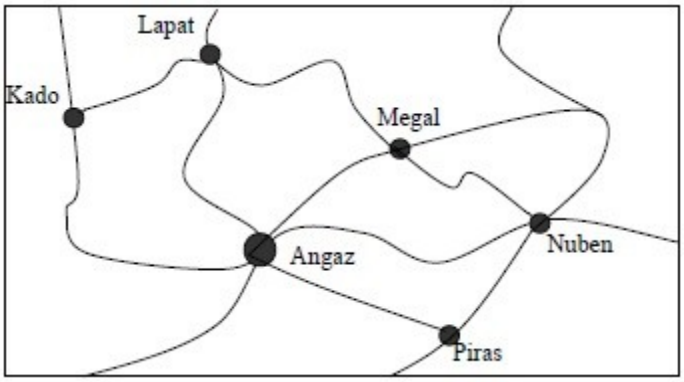


Figure 2: Shortest road distance of towns from each other in kilometres.

Angaz					
Kado	550				
Lapat	500	300			
Megal	300	850	550		
Nuben	500		1000	450	
Piras	300	850	800	600	250

Question 1: TRIP

Question intent: Decision Making

Calculate the shortest distance by road between Nuben and Kado.

Distance: ..... kilometers.

Question 2: TRIP

Question intent: Decision Making

Zoe lives in Angaz. She wants to visit Kado and Lapat. She can only travel **up to 300 kilometres** in any one day, but can break her journey by camping overnight anywhere between towns.

Zoe will stay for **two nights** in each town, so that she can spend one whole day sightseeing in each town.

Show Zoe's itinerary by completing the following table to indicate where she stays each night

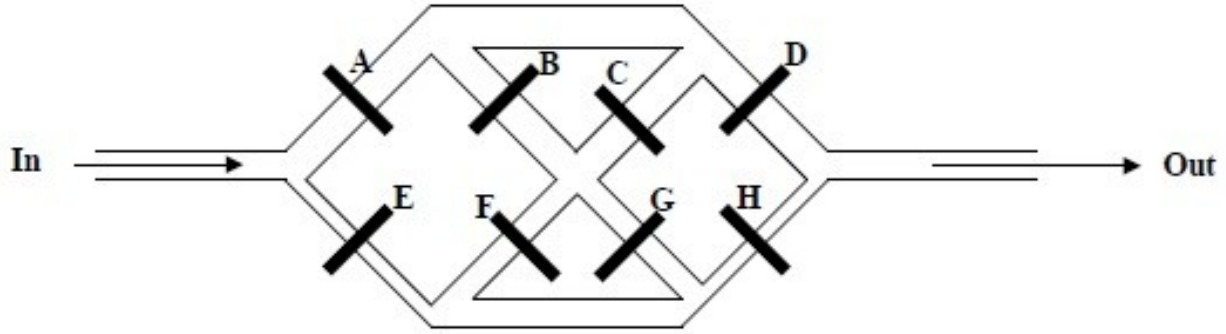
Day	Overnight Stay
1	Camp-site between Angaz and Kado.
2	
3	
4	
5	
6	
7	Angaz

IRRIGATION

Below is a diagram of a system of irrigation channels for watering sections of crops. The gates A to H can be opened and closed to let the water go where it is needed. When a gate is closed no water can pass through it.

This is a problem about finding a gate which is stuck closed, preventing water from flowing through the system of channels.

Figure 1: A system of irrigation channels



Michael notices that the water is not always going where it is supposed to.

He thinks that one of the gates is stuck closed, so that when it is switched to “open”, it does not open.

Question 1: IRRIGATION

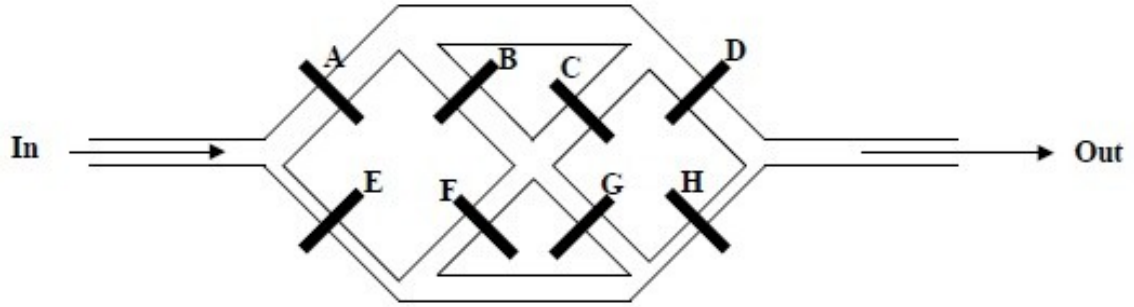
Question intent: Trouble Shooting

Michael uses the settings given in Table 1 to test the gates.

Table 1: Gate Settings

A	B	C	D	E	F	G	H
Open	Closed	Open	Open	Closed	Open	Closed	Open

With the gate settings as given in Table 1, **on the diagram below** draw all the possible paths for the flow of water. Assume that all gates are working according to the settings.



Question 2: IRRIGATION

Question intent: Trouble Shooting

Michael finds that, when the gates have the Table 1 settings, no water flows through, indicating that at least one of the gates set to "open" is stuck closed.

Decide for each problem case below whether the water will flow through all the way. Circle "Yes" or "No" in each case.

Problem Case	Will water flow through all the way?
Gate **A** is stuck closed. All other gates are working properly as set in Table 1.	Yes / No
Gate **D** is stuck closed. All other gates are working properly as set in Table 1.	Yes / No
Gate **F** is stuck closed. All other gates are working properly as set in Table 1.	Yes / No

Question 3: IRRIGATION

Question intent: Trouble Shooting

Michael wants to be able to test whether **gate D** is stuck closed.

In the following table, show settings for the gates to test whether **gate D** is stuck closed when it is set to "open".

Settings for gates (each one "open" or "closed")

A	*B*	*C*	*D*	*E*	*F*	*G*	*H*

Innovation Capital

Innovation Capital

The *Group of Eight* or *G8* is a group comprised of political representatives of eight of the world's largest eleven economies: United States, United Kingdom, Canada, Germany, France, Italy, Japan and Russia. The *G8* meet periodically to discuss issues of importance to member states and agree upon measures to address these issues.

The countries that comprise the *G8* have been experiencing slow economic growth in recent years, and this is an important topic to be discussed at the next meeting of *G8* Finance Ministers. In preparation for this meeting, a McKinsey team, working together with a group of external thought leaders and academics, are preparing a report on the importance of Innovation as a contributor to economic growth. The team intends to introduce a concept to the *G8* representatives known as 'Innovation Capital', which is the value of all innovation-related assets which contribute to growth in productivity in the economy.

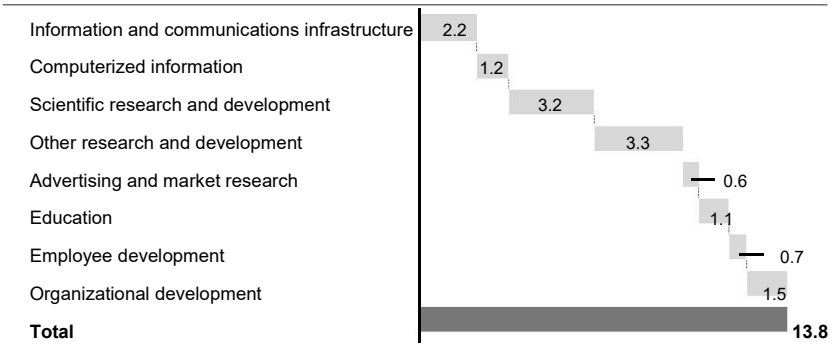
The team further defines three types of Innovation Capital:

- **Physical Capital:** Investments in information and communication equipment
- **Knowledge Capital:** Investments that build the intellectual property and brand value of a company or organization
- **Human Capital:** Investments that build individual or group abilities and skills within companies or organizations

Exhibit 1 shows the main components of Innovation Capital and their total value across 16 countries that the team has been studying, including the members of the *G8*.

Exhibit 1

Total innovation capital, (US$ trillions)



Innovation Capital

1. Which of the following MOST accurately describes the reason for the team's work in preparing for the *G8* meeting?
   A. The team has discovered a new economic measure known as Innovation Capital and wants to introduce it
   B. The team wants to explain how Innovation can drive economic growth
   C. The team wants to explain how Innovation can represent a large proportion of an economy's size
   D. The team wants to convince the group to invest more in Innovation Capital in the future

2. Which of the following analyses would be LEAST appropriate in better understanding the size of investments in Innovation Capital in the countries the team has been studying?
   A. Analysis of expenditure by organizations on training programs for their employees
   B. Analysis of expenditure by organizations on activities which build awareness of their aims and purpose
   C. Analysis of expenditure by organizations on networking and socialization meetings and events
   D. Analysis of expenditure by organizations on the management of their databases and information systems

3. Which of the following can be concluded based on the information provided in Exhibit 1 regarding the countries being studied?
   A. 45% of all Human Capital is invested in Organizational Development
   B. 51% of all Innovation Capital is Knowledge Capital
   C. More than 10% of Innovation Capital is invested in Computerized Information
   D. More than a quarter of Innovation Capital is Scientific Research & Development

4. If total Innovation Capital in Exhibit 1 were to grow by 5% per year in the future, which of the following would be the MINIMUM required annual growth in Human Capital that would see it represent more than half of total Innovation Capital in 10 years?
   A. 10%
   B. 15%
   C. 20%
   D. 25%

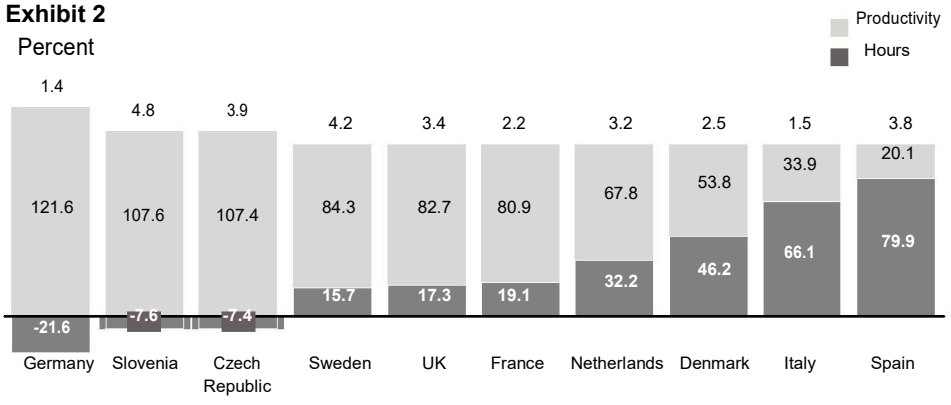
The team proceeds to examine changes in business sector growth in a number of European countries in recent years, that is, the change in the total value of goods and services produced by the business sectors in these countries.

Growth in the value of goods and services can be driven by two factors:

- **Hours:** Changes in the total hours worked can drive changes in the total goods and services produced
- **Productivity:** Even if the same number of hours have been worked, a more or less productive workforce can generate greater or lesser goods and services.

Exhibit 2 shows the average contribution of these two factors towards business sector growth in ten European countries over the last 12 years. Average annual business sector growth is given at the top of each bar. Within each bar, the light grey portion represents the proportion of this growth driven by changes in Productivity, while the dark grey portion represents the proportion of this growth driven by changes in Hours.

Exhibit 2
Percent



5. Which of the following statements, if true, would BEST explain why the information in Exhibit 2 is important for the team?
   A. Most of the countries in Exhibit 2 have experienced negative economic growth in the last 2 years
   B. In most countries, the business sector is the biggest contributor towards Innovation Capital
   C. Growth in Hours is mostly driven by growth in the size of the working population
   D. Growth in Productivity is mostly driven by growth in Innovation

6. Which of the following statements is TRUE based on the information provided in Exhibit 2?
   A. Hours grew by 24% across all ten countries over the last 12 years
   B. Slovenia had the greatest growth in Productivity over the last 12 years
   C. Spain had the least growth in Productivity over the last 12 years
   D. Germany had the least growth in Hours over the last 12 years

7. To the nearest tenth of a percentage point, what is the difference between Germany's and Spain's average annual business sector growth due to productivity over the last 12 years?
   A. 0.1 percentage points
   B. 0.5 percentage points
   C. 0.9 percentage points
   D. 1.3 percentage points

8. Which of the following, if true, LEAST explains the data for Slovenia and Czech Republic in Exhibit 2?
   A. Over the last 20 years, the average age of the population in these countries has been steadily increasing
   B. Prior to the period in Exhibit 2, these countries were emerging from Communist economies with comparatively poor infrastructure and productivity
   C. Net migration into these countries has been negative over the last 12 years
   D. Changes in employment laws in these countries have led to greater flexibility for employers in setting working hours for their employees

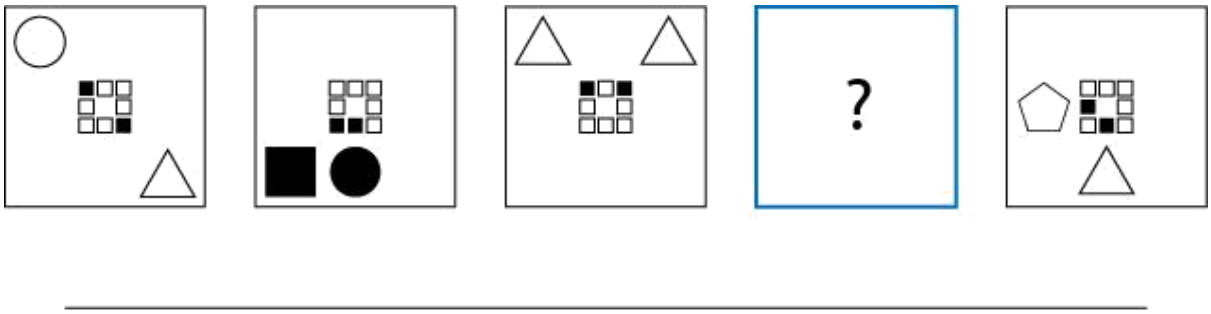
In preparing further for the *G8* meeting, the team decides that it would be a good idea to use some specific examples of recent major innovations to help better explain the importance of Innovation Capital.

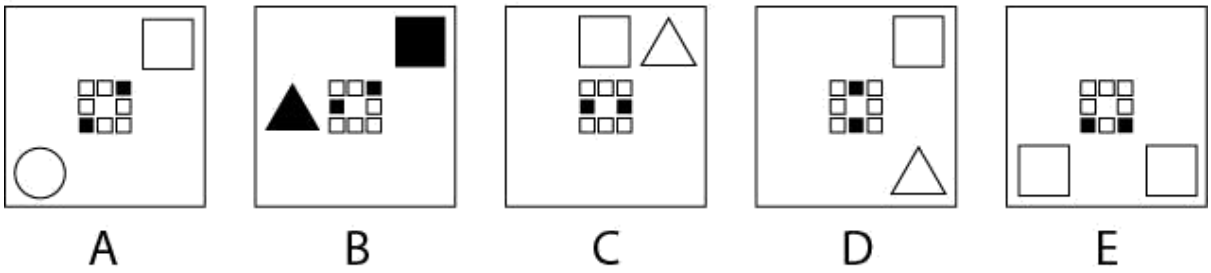
A team member suggests using Apple's *iPod* music player as such an example. The team readily agrees to this suggestion. They believe that the development of the *iPod* not only illustrates all three types of Innovation Capital, but it also shows how up-front investment in Innovation Capital can lead to follow-on advantages for the investor that accumulate over time.

9. Which of the following statements LEAST illustrates the Innovation Capital underlying the development of Apple's *iPod*?
    A. New software and technology was required to allow the distribution of music through online channels
    B. New pricing was negotiated with the music industry to encourage online music purchasing
    C. New design concepts were developed that gave the product an appealing look and feel
    D. A new way of working with the music industry was developed to allow rapid distribution of new music to *iPod* users

10. Which of the following analyses would BEST illustrate the team's beliefs regarding Apple's *iPod*?
    A. An analysis of the market share achieved by Apple for its products subsequent to the *iPod*
    B. An estimate of the size of the investment made by Apple in the development of the *iPod*
    C. An estimate of the profit margins of the music industry subsequent to the launch of the *iPod*
    D. An analysis of the reactions of technology experts to the *iPod* and subsequent Apple products

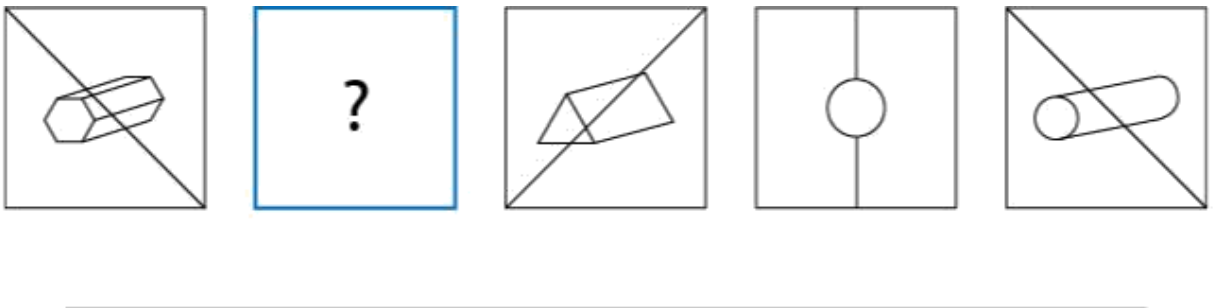
Appendix 4:Inductive Reasoning Free Sample Test 2

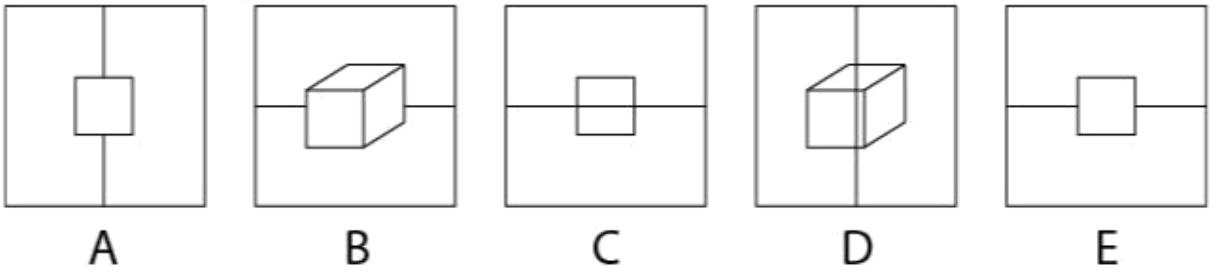




Q1 What replaces the question mark?

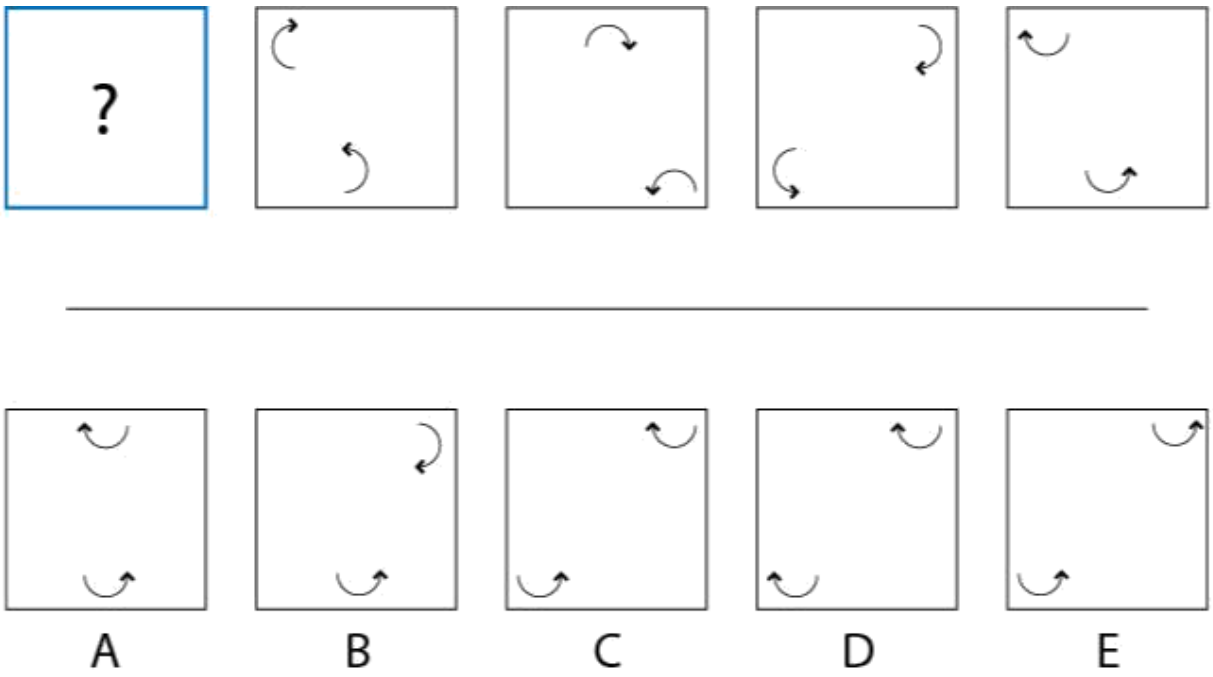
(A) A
(B) B
(C) C
(D) D
(E) E





Q2 What replaces the question mark?

(A) A
(B) B
(C) C
(D) D
(E) E

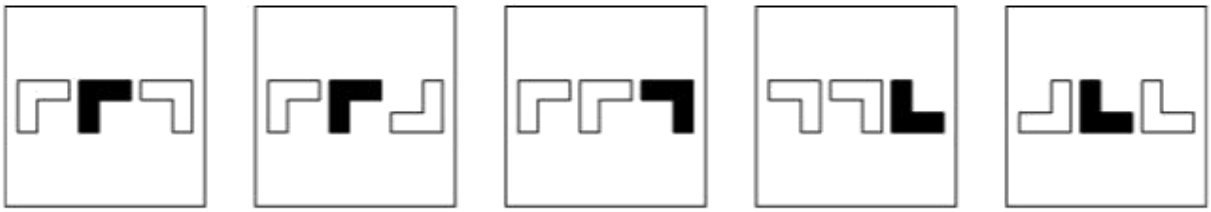


Q3 What replaces the question mark?

(A) A
(B) B
(C) C
(D) D
(E) E

Q4 What replaces the question mark?

(A) A
(B) B
(C) C
(D) D
(E) E

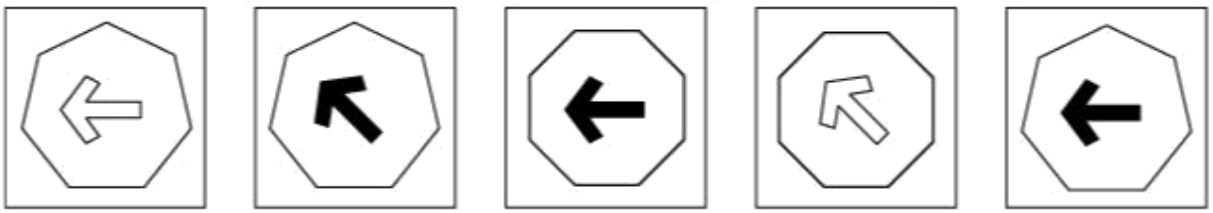


Q5 What replaces the question mark?

(A) A
(B) B
(C) C
(D) D
(E) E

Q6 What replaces the question mark?

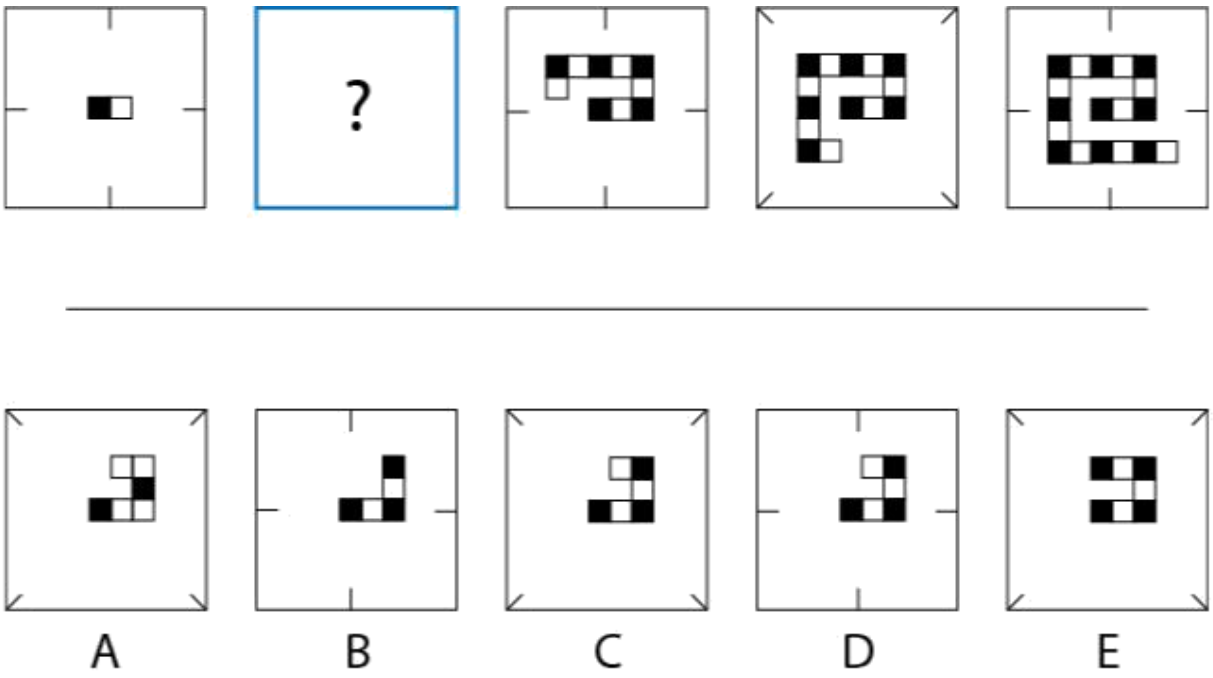
(A) A
(B) B
(C) C
(D) D
(E) E



A B C D E

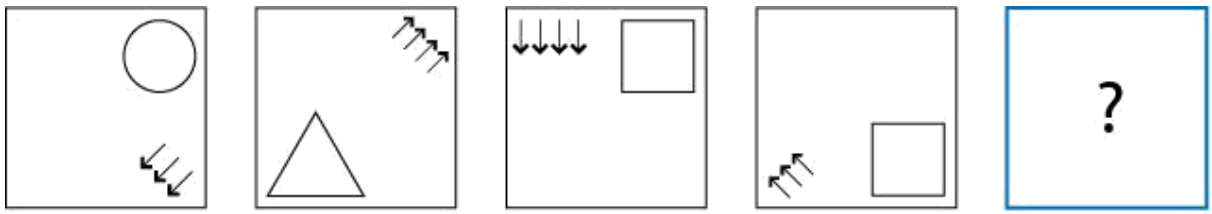
Q7 What replaces the question mark?

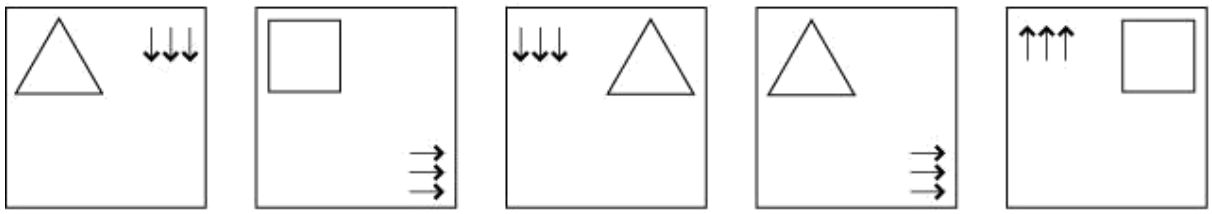
(A) A
(B) B
(C) C
(D) D
(E) E



Q8 What replaces the question mark?

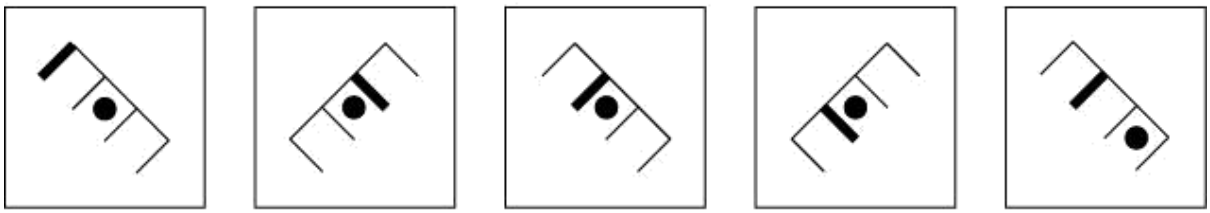
(A) A
(B) B
(C) C
(D) D
(E) E





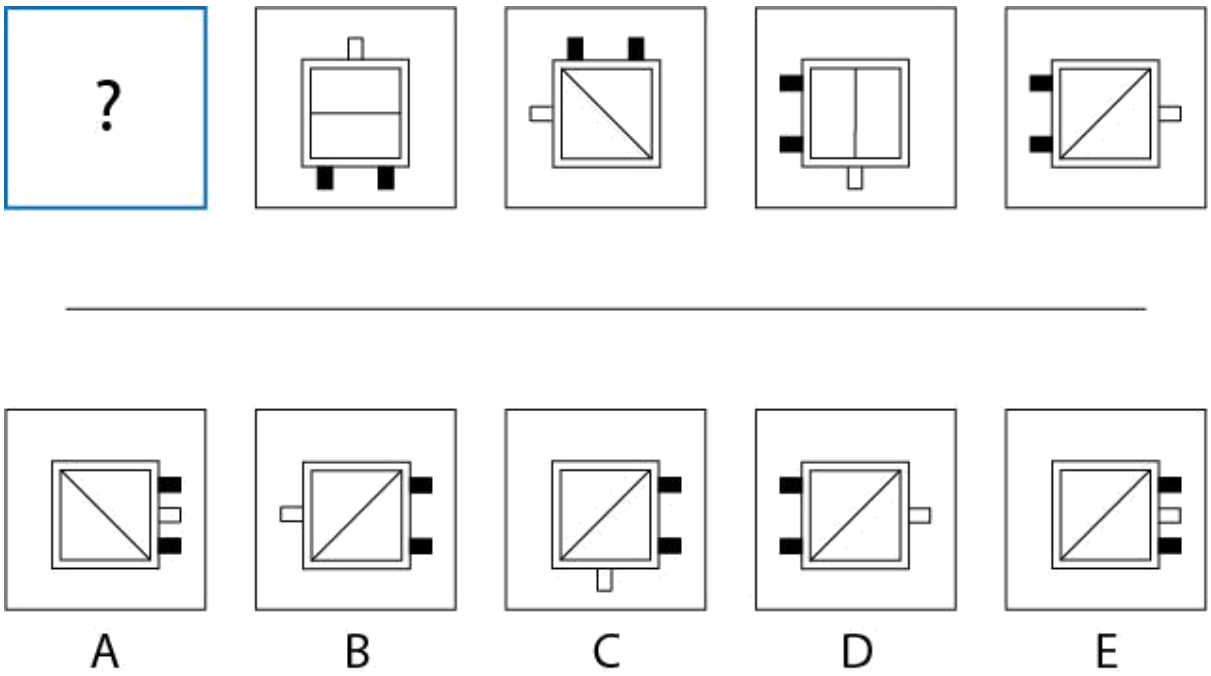
Q9 What replaces the question mark?

(A) A
(B) B
(C) C
(D) D
(E) E



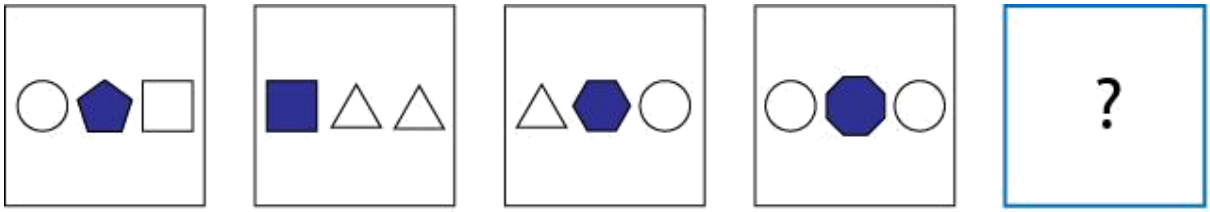
Q10 What replaces the question mark?

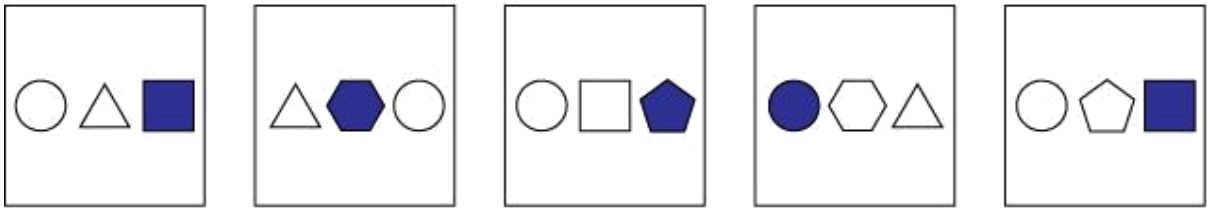
(A) A
(B) B
(C) C
(D) D
(E) E



Q11 What replaces the question mark?

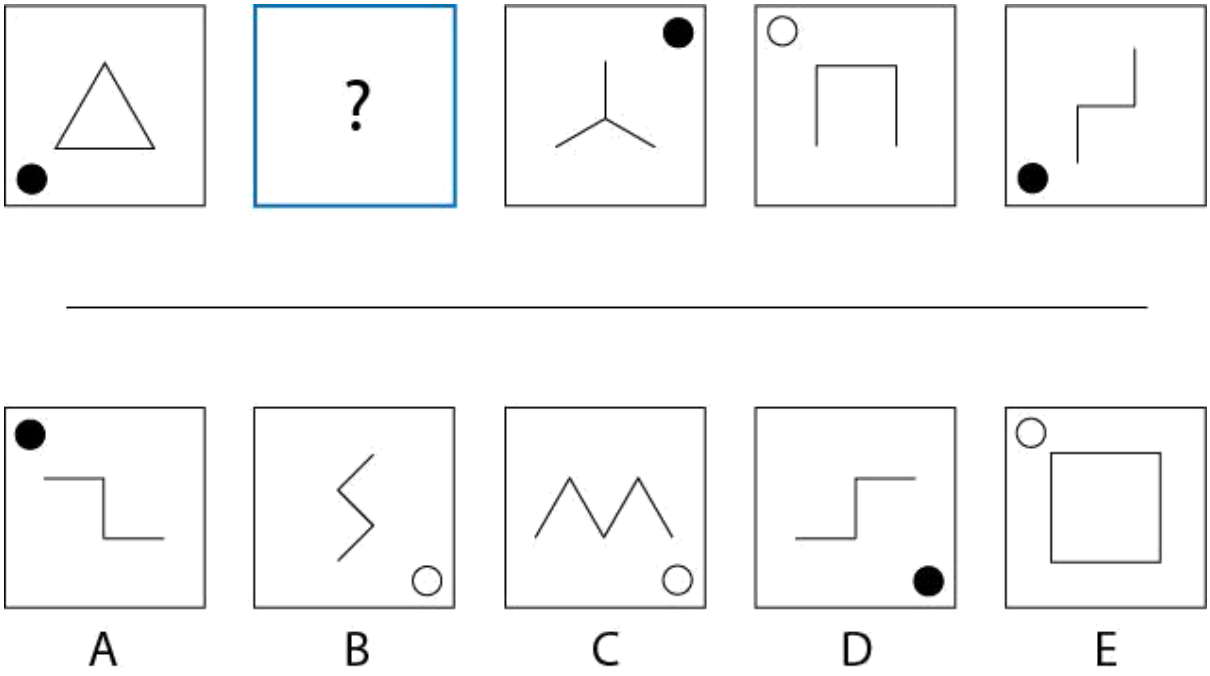
(A) A
(B) B
(C) C
(D) D
(E) E





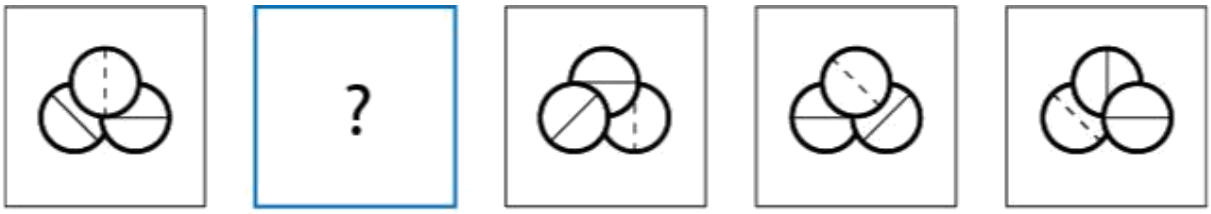
Q12 What replaces the question mark?

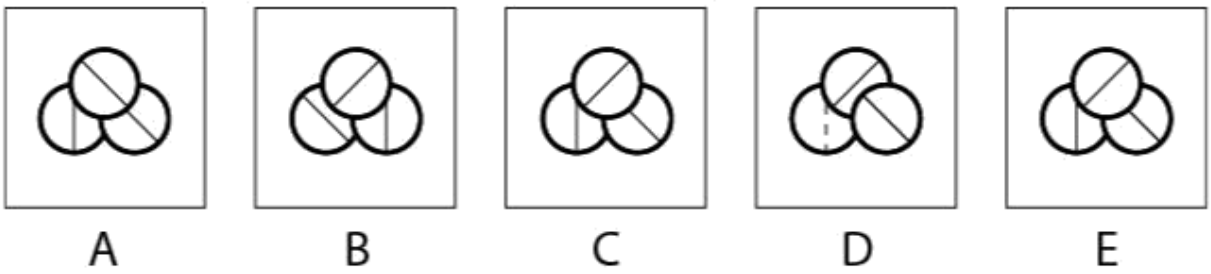
(A) A
(B) B
(C) C
(D) D
(E) E



Q13 What replaces the question mark?

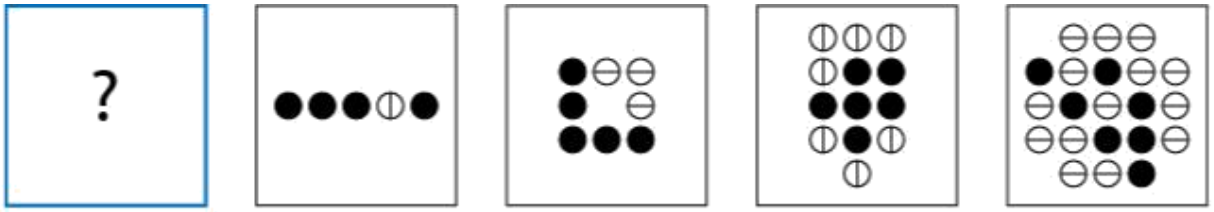
(A) A
(B) B
(C) C
(D) D
(E) E

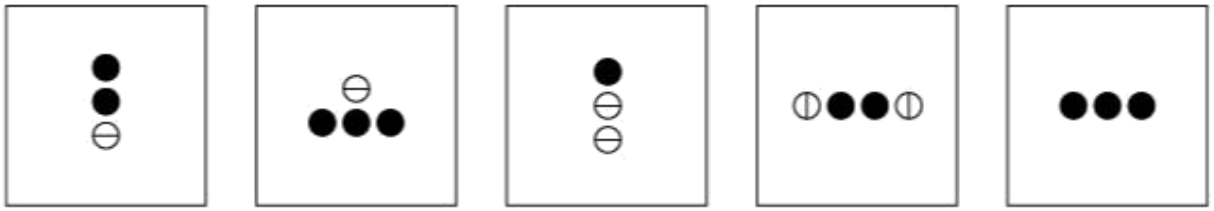




Q14 What replaces the question mark?

(A) A
(B) B
(C) C
(D) D
(E) E





Q15 What replaces the question mark?

(A) A
(B) B
(C) C
(D) D
(E) E

-- End of Test --