GL Assessment®

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CAT4 AND STRATEGIES FOR LEARNING

COGNITIVE ABILITIES TEST

Published by GL Assessment
1st Floor, Vantage London, Great West Road, Brentford TW8 9AG
www.gl-assessment.co.uk
ISBN 978-0-7087-2808-6

Typeset by Mike Connor Design and Illustration

2(01.20)

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CAT4 and strategies for learning

Results from *CAT4* enable teachers to adapt their teaching approaches, materials, emphasis and pace in the classroom to meet individual student needs. This is enhanced by an understanding of the interaction between student characteristics and the demands of the task or the classroom. The effective teacher will use all these factors to directly impact each student's learning outcomes.

Careful consideration of the results from *CAT4* can be used to identify strengths and weaknesses in an individual student's cognitive abilities, which are not easy to assess through other methods. Knowledge of a student's cognitive strengths and weaknesses provides valuable insight, which has important implications for how best to support their learning.

Success in school depends on many personal and social factors. For example, different students are motivated by different things: some may be motivated by an interest in the subject matter, some by a need for achievement or competition, and others by a fear of failure. Students may differ in their self-esteem, the amount of effort they are willing to put in, their confidence or social skills and whether they are prepared to persevere with tasks. All of these factors can affect their success.

For students, learning will be enhanced when they are interested and engaged, but impaired when they are anxious. The same task that engages one student (for example, a spoken presentation to the class) may make another student anxious. It is these interactions between teacher and student that influence the effectiveness of the learning that takes place.

This guide will deal with an important aspect of *CAT4* results, including some guidance which is *CAT4* specific, and some which can be applied even without *CAT4*. Other important aspects of *CAT4*, such as setting valid targets for students or judging differences over time or groups, will not be covered in as much detail. For readings on these aspects we recommend you use the Cognitive Abilities Test Teacher Guidance Pack.

Learning strategies for different *CAT4* profiles

CAT4 assesses four types of reasoning, one for each of the four batteries, which each contain two tests.

- **Verbal Reasoning**: the ability to understand ideas and reason through words is essential to subjects with a high language content and the most obvious skill picked up by traditional assessment.

The Verbal Reasoning Battery comprises two short tests: Verbal Classification and Verbal Analogies.

- **Quantitative Reasoning**: the ability to use numerical skills to solve problems – applicable well beyond mathematics. The Quantitative Reasoning Battery comprises two short tests: Number Analogies and Number Series.
- **Non-verbal Reasoning**: problem-solving using pictures and diagrams – skills which are important in a wide range of school subjects, including maths and science-based subjects. The Non-verbal Reasoning Battery comprises two short tests: Figure Classification and Figure Matrices.
- **Spatial Ability**: the capacity to think and draw conclusions in three dimensions, especially important for many STEM subjects (science, technology, engineering and mathematics) but not easily measured by other sources of information. The Spatial Ability Battery comprises two short tests: Figure Analysis and Figure Recognition.

Learning activities differ in the extent to which they require students to process information in verbal, quantitative, non-verbal or spatial forms. In lessons, students are likely to be presented with written texts, graphs or diagrams, video clips, tabulated data, maps or other forms of information. They may be asked to take notes, to record numerically, to discuss their sources, to translate their results as charts, or to make written reports or oral presentations. A student's ability to interpret, analyse and reason in these different media may vary greatly.

When possible, teachers should allow students to use their better-developed abilities in one area to support or scaffold their learning in another. For example, a student with strong verbal but poor quantitative reasoning ability might improve the latter through discussion about mathematical concepts or problems, rather than just working silently on worksheets or a computer.

This chapter will detail how these reasoning abilities can support and enhance the learning of all students with the widest range of **appropriate strategies**. The strategies presented here are not a basic guide to teaching, but are meant as points for a teacher to reflect upon whether their practice is striking the optimal balance between demonstration, questioning, use of materials, etc. We draw on cognitive psychological research to shed light on why some methods might be more effective than others.

Recent evidence suggests there are core elements that are effective in nurturing the conditions for great learning. Many of these are referred to in this document, as well as specific strategies to support hypothetical examples of *CAT4* results. Although the examples are

hypothetical, they exemplify the types of *CAT4* results that will be familiar to teachers who use *CAT4* in their practice.

Profiles and what to expect

The strategies presented in this document form part of the provision of effectively applying learning strategies for different *CAT4* profiles and feedback to students, rather than an expectation that teachers adopt an approach to teaching students that reflects a student's personal learning style. It is now acknowledged that the concept of individual student learning styles – for example, visual, auditory and kinaesthetic – is invalid. A significant amount of research since the early 2000s (including that undertaken by Coffield at both the University of Newcastle and the Institute of Education in the UK) has demonstrated that there is no good scientific evidence that learning styles actually exist, even though the theory has been enthusiastically adopted in many countries and states around the world. Indeed, a study from 2014 indicated that more than 90% of teachers in various countries believed it.

Likewise, *CAT4* results should not be used to restrict the range of educational possibilities that a student will receive. *Our cognitive abilities and preferences are not fixed* at birth and we all have a degree of 'neural plasticity' that allows us to achieve a level of expertise in a wider range of knowledge, skills and understanding than we may have thought. Although a group of *CAT4* results has rank stability over time, it still allows a range of movement of an individual's developmental trajectory. For example, GL's indicators for *CAT4* show that a range of students with a single *CAT4* score will achieve a range of outcomes since nothing is determined purely from cognitive ability.

Students' reasoning skills can be further improved by encouraging them to *find ways of communicating accurately and imaginatively* to describe more precisely the relationships among concepts or the rules that sequence them.

For example, in writing, teachers should encourage students to be as clear or as imaginative as possible in their use of words, phrases and sentences, and challenge them to explain their choices. Students could also be encouraged to monitor their own thinking and problem-solving by recording the processes that they have gone through using a written record, concept or memory map. Many of these ideas will be returned to in later sections.

This does not diminish the importance of identifying a student's cognitive strengths through the *CAT4* test programme. In fact, the introduction of the Spatial Ability Battery in *CAT4* provides a new way for teachers to help students realise their potential in the classroom. This document recognises the value of using all the batteries in an

integrated way to offer insights into how a range of different strategies can be used to support learning. The identification of a particular cognitive strength can be used effectively to promote learning development in other areas.

It is important to consider the level of the *CAT4* scores as well as the specific area of strength or weakness. A significantly lower score on the Verbal Battery than on the Spatial Battery may have different implications if the level of the verbal score is low (say, 85) or if it is high (say, 115). For example, the former might suggest a focus on core aspects of literacy, while the latter might suggest a wider focus on extending verbal concepts and higher-order verbal thinking. Nevertheless, teachers should consider how the relative spatial and non-verbal strengths of both students could be used to support their learning in the verbal area.

Understanding how we learn: cognitive psychology

Cognitive psychology researchers have greatly improved our understanding of how we learn. Much of the research has implications for teachers in the classroom, and a number of key initiatives, including the UK's researchED programme, aims to bridge academic research and classroom practice. Teachers, researchers and bloggers have taken the key findings from Hattie (2012) *Visible Learning* meta-analyses of hundreds of studies and used them in real-world contexts.

What makes great teaching?, a Sutton Trust report by Coe et al. (2014), illuminates how many learning strategies used regularly by students (and often recommended by teachers) have little effect on learning. The report identifies that many of these ineffective practices are popular even though empirical evidence for any efficacy is very limited. There are seven specific practices which are not supported by research evidence.

1. Using lavish praise:

This approach, particularly when used with low-attaining students, is more likely to convey a message of low expectations (Dweck, 1999; Hattie and Timperley, 2007).

> *Praise for successful performance on an easy task can be interpreted by a student as evidence that the teacher has a low perception of his or her ability. As a consequence, it can actually lower rather than enhance self-confidence.*
>
> Stipek (2010)

2. Discovery learning:

Allowing learners to discover key ideas for themselves is a major feature of some international curriculums but the value of discovery learning is not supported by research, which broadly favours direct instruction (Kirschner et al., 2006). However, as with interpretation of many research findings, much depends on the detail. For example, homework is found to have a more significant impact at secondary level than at primary level.

The effectiveness of any kind of enquiry-based, constructivist approach to learning will be determined by its delivery in the classroom. Proponents of this approach believe that discovery learning encourages active engagement and motivation, and that it helps to develop responsibility and independent learning and problem-solving skills. Critics would argue that it creates cognitive overload and makes it difficult for teachers to detect learners' misconceptions. However, it is the teacher's 'quality of thought and effort' that will really determine the effectiveness of any one strategy.

3. Grouping learners by ability ('sets' or 'streams'):

This is a strategy widely used in education systems around the world – but there appears to be little evidence that it makes a positive difference to learning outcomes (Higgins et al., 2014). The Education Endowment Foundation review suggests that indeed it has a mildly negative difference to learning outcomes.

Although ability grouping can, in theory, allow teachers to target a narrower range of pace and content of lessons, it is equally likely to create an exaggerated sense of homogeneity within any group. Even the most rigorously set group will contain a wide range of different abilities in different areas of learning and, of course, this is where an empirical test like *CAT4* can be useful in identifying the extensive learning variables within any group.

4. Encouraging re-reading and highlighting to memorise key ideas:

This is one of the most common study approaches when revising or attempting to memorise material. Indeed, for some students it may well be the only way they prepare for a test or examination. But a range of studies – for example, Brown et al. (2014) – has shown that testing yourself, trying to generate answers and deliberately creating intervals between study to allow for forgetting are all more effective approaches.

5. Strategies to boost confidence:

Dealing with students' low levels of confidence and reduced aspirations, before teaching any content, also appears to have limited value. Even if the outcome of such support strategies is more motivated students, the impact on their actual learning appears to be small (Gorard et al., 2012). More than this, the poor motivation of low attainers is seen by Coe et al. (2014) as "a logical response to repeated failure". He suggests instead that teachers "start getting [students] to succeed and their motivation and confidence should increase".

6. Preferred learning styles:

The efficacy of presenting information to learners in their preferred learning style remains a persistent myth in education. Indeed, the Dekker et al. (2012) study showed that 93% of teachers in the UK agreed with the statement that "Individuals learn better when they receive information in their preferred Learning Style (e.g., auditory, visual, kinaesthetic)", and a 2014 survey reported that 76% of UK teachers "used Learning Styles" because they felt that this benefited their students in some way (Simmonds, 2014).

However, it is more likely that some of the harmful effects of the learning-styles approach will impact negatively on students' learning. These include 'pigeonholing' learners according to invalid criteria, creating inappropriately 'differentiated' resources and creating unrealistic expectations of a now-discredited approach.

7. Active learning only:

The belief that for improved learning students should always be active learners, rather than sometimes listening passively, is also an education myth. This claim is often presented in the form of the 'learning pyramid' which shows percentages of material that will be retained when different levels of activity are employed.

Memory: working and long-term

Cognitive psychology research has identified working memory as a key concept in understanding how we learn. Working memory can be described as the systems in our brains that hold short-term (i.e., temporary) information while using that information to accomplish a task. A simple example would be trying to remember a phone number after we have heard it from a friend or over the phone. If the number is given to us in two stages – for example, the first three digits and then the next group – our working memory has to try and remember the

second group while we write down the first. The first three digits are stored in our working memory temporarily. Experiments indicate that we can only hold a few items in our short term memory and for a very limited time only. Unless we use a strategy to try and remember this information it will simply disappear (Figure 1).

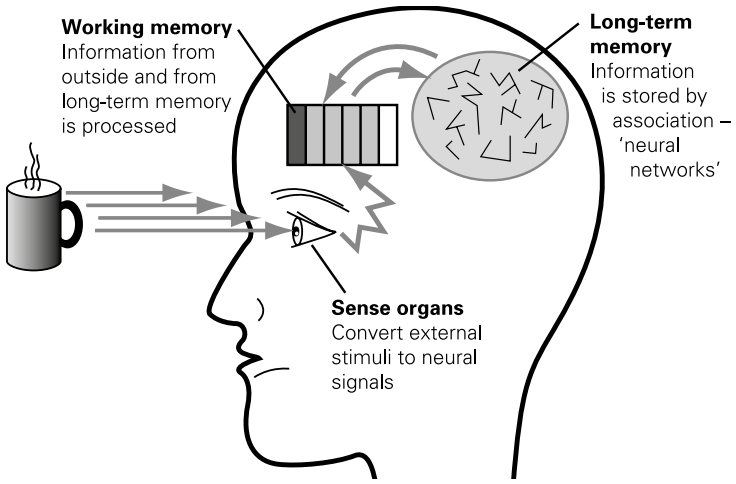


Figure 1 Transfer of information from short-term to long-term storage. "Figure 7.6" from Psychology in Your Life, Second Edition by Sarah Grison, Todd F. Heatherton, and Michael S. Gazzaniga. Copyright 2017, 2015 by W.W. Norton & Company, Inc. Used by permission of W.W. Norton & Company, Inc.

Using one or more strategies to do this is what we call memorisation – but how do we improve the ability to remember? John Sweller's Cognitive Load Theory is an important concept here – indeed, in January 2017 Dylan Wiliam tweeted that he had "come to the conclusion that Sweller's Cognitive Load Theory (CLT) was the single most important thing for teachers to know." This is certainly a bold claim, but elsewhere Wiliam has been more specific about its significance:

> *The important point about Sweller's cognitive load theory is not the limited capacity of human working memory— this has been known for decades. The innovative finding of CLT is that learning tasks that require cognitive loads that exhaust students' working memory may be successfully completed, but that no long-term learning results. In other words, students can satisfactorily complete a learning task, but not learn what the task is intended to teach...*
>
> Wiliam (2019)

Cognitive Load Theory shows us that working memory can be extended in two key ways. The first is the recognition that the mind processes visual and auditory information separately. This is sometimes called the Modality Effect and recent interest in Alan Paivio's Dual Coding theory reflects this. The second is that working memory treats a chunk of information that the brain already knows as one item, the 'size' of which is dependent on how deeply we know or understand this information.

So new learning that is connected to existing knowledge will be more easily assimilated and is also able to increase the capacity of the working memory and aid storage in our long term memories.

One particularly interesting finding is described by researchers Bjork and Bjork (2014) like this:

> *Basically, any time that you, as a learner, look up an answer or have somebody tell or show you something that you could, drawing on current cues and your past knowledge, generate instead, you rob yourself of a powerful learning opportunity.*

In a memorable phrase, Willingham calls memory "the residue of thought". Simply, you remember what you think about. This is the first of three key principles that Willingham suggests can guide students wishing to improve their memories. The second principle is that memories may not be accessed due to missing or ambiguous clues – for example, when we can't remember someone's name but we can remember which letter of the alphabet it begins with. Willingham's third principle is that we tend to believe that our learning is more thorough than it really is.

As we know from experience, the evidence suggests that students are not absolutely passive sponges, nor does learning have to be active all the time, but being comfortable with both styles and knowing how to find a balance is important as a teacher. This theme will develop in later sections, after we have recapped our understanding of *CAT4*.

Understanding *CAT4* results

If at any stage you have a question about CAT4 *data or your* CAT4 *results, please contact our Assessment Insights team at Assessment.Insights@gl-assessment.co.uk. Our Assessment Insights team are assessment data experts with over 35 years combined classroom experience, here to help you make the best use of your data to inform in-school actions. You are also welcome to book a free one-to-one data consultation where the team will review your data in advance, provide an objective summary of key findings and help you to identify next steps.*

A student's *CAT4* results provide a detailed and objective analysis of their reasoning abilities. The results can identify strengths and weaknesses, what these might reveal about the student's learning and then indicate which learning strategies might be most effective. When teachers have an awareness of both the strengths of an individual and the abilities demanded by a particular task, learning will be most successful.

The **Standard Age Score (SAS)** is the most important piece of information derived from *CAT4*. The SAS is based on the student's raw score which has been adjusted for age and placed on a scale that makes a comparison with a nationally representative sample of students of the same age across the UK. The average score is 100. The SAS is key to benchmarking and tracking progress and is the fairest way to compare the performance of different students within a year group or across year groups.

Schools that are based outside of the UK use SAS that are based on UK standardisation. Many schools follow a UK curriculum and their students take external assessments such as the GCSE or IGCSE, and for these it is important to know how their cohorts compare to students taught the same curriculum within the UK. The skills assessed by *CAT4* are independent of a taught curriculum and can therefore be applied to an international context.

The SAS for each of the four batteries are given separately in the Individual Report and are averaged to give the **mean score**. When thinking about learning strategies, it is particularly important to focus on students' scores in the four *CAT4* batteries rather than on their mean *CAT4* score.

Understanding the difference between *CAT4* Level X & Y standard age score reporting and the other *CAT4* levels

When comparing standard age scores (SAS) between *CAT4* Level X & Y and the other levels of *CAT4*, it is important to note that whereas the range of scores from levels A to G is from 59 to 141, the range of scores for levels X & Y ranges from 69 to 131.

There is a simple explanation for this difference. *CAT4* levels X and Y are designed to test younger students who typically have a shorter attention span than older students. As a result, they are administered in two parts of 30 minutes rather than in three parts of 40 minutes. This change in design allows us to create a test that is appropriate for these younger students, but with fewer questions and less data it is not possible to reliably differentiate between extremely strong scores above 131 and extremely weak scores below 69. Note that only the bottom 2% and top 2% of children's results will have standard age scores that are affected by the different limits. In addition, these children will receive the same Stanine and almost all will receive the same National Percentile Rank (NPR).

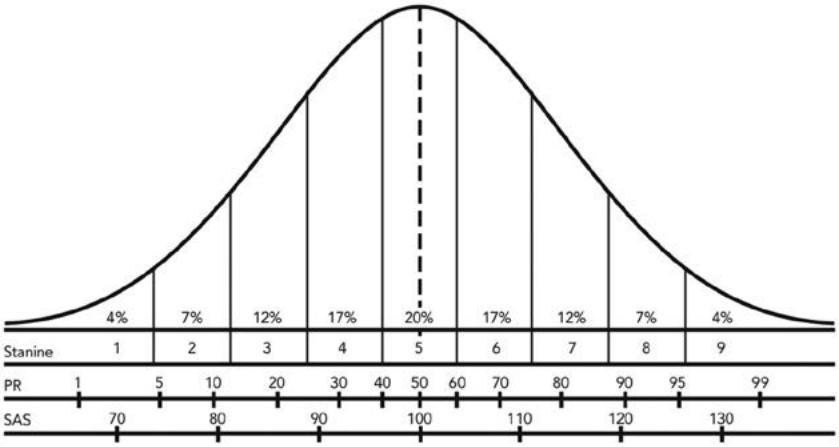
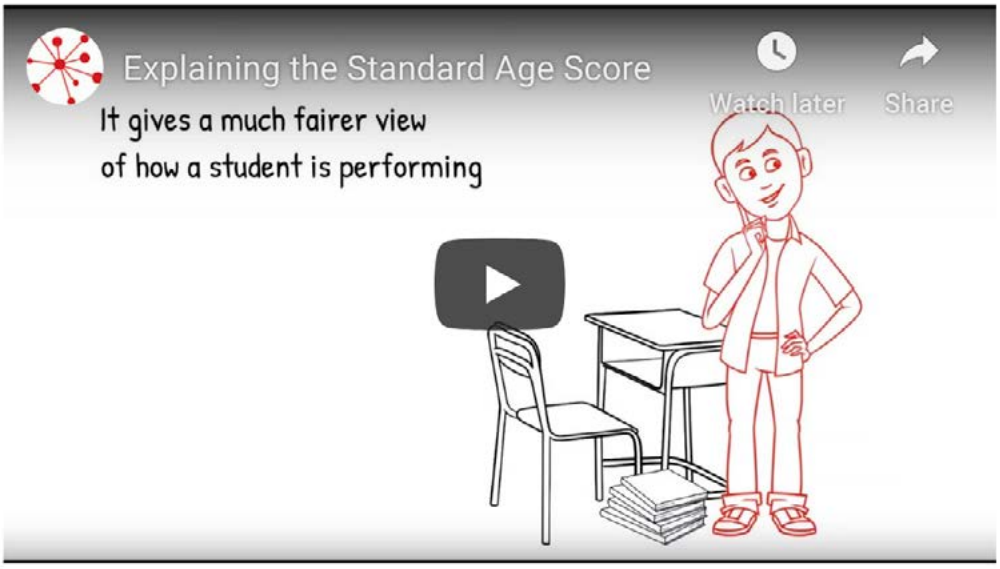


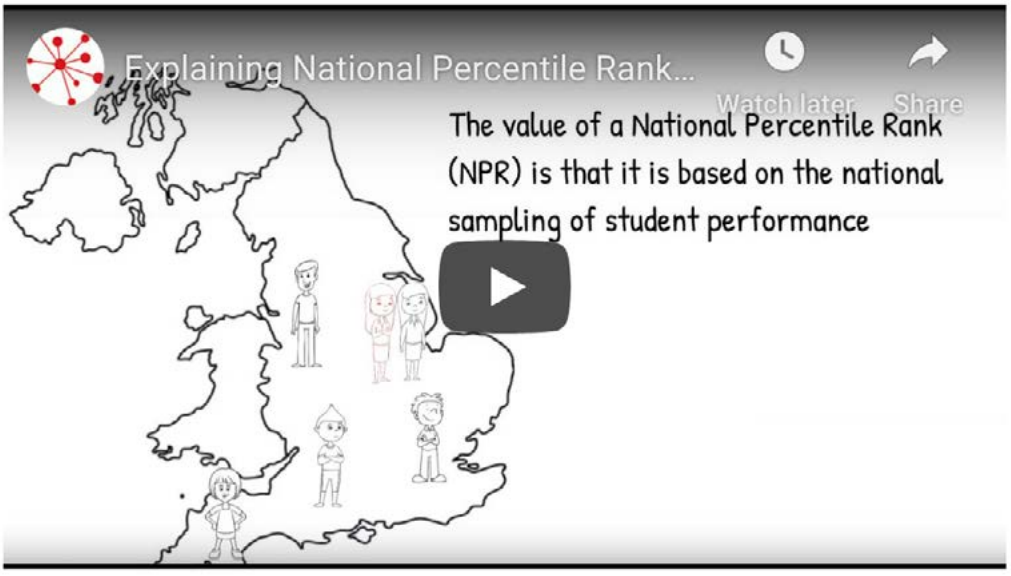
Figure 2 Distribution of standard age score, percentile rank (PR) & standard deviation from mean

Explaining the Standard Age Score

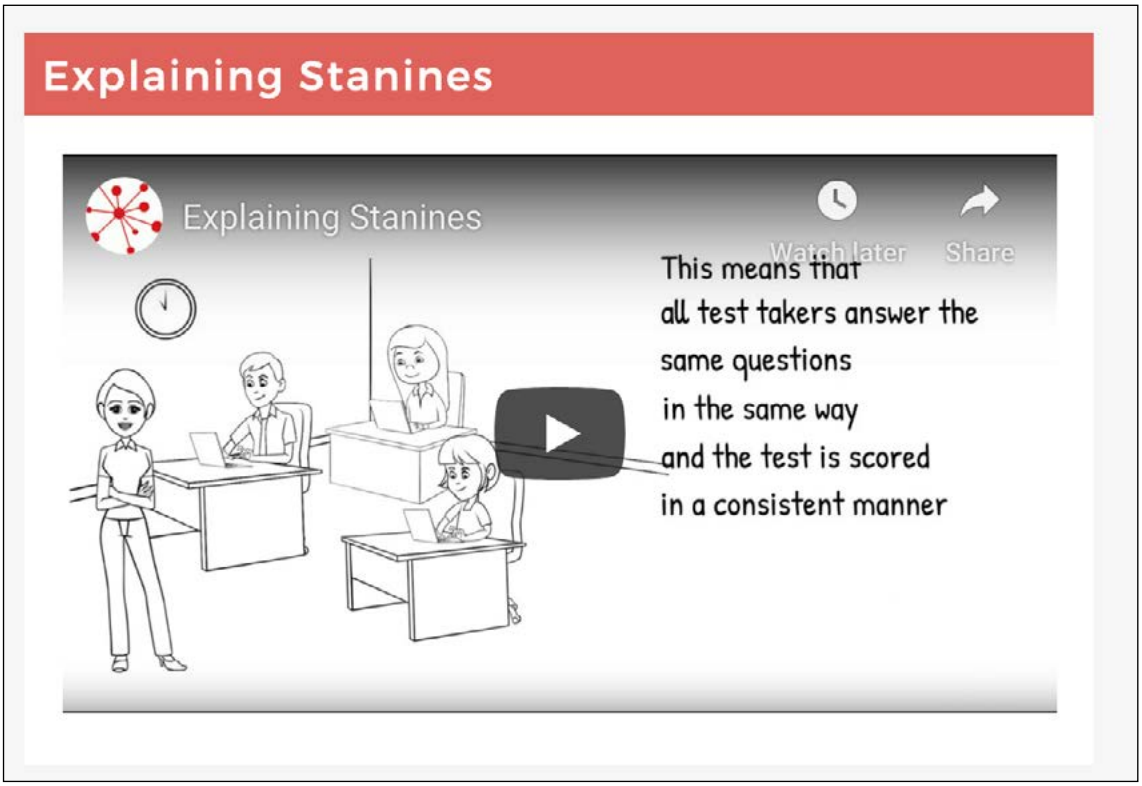


The **National Percentile Rank (NPR)** relates to the SAS and indicates the percentage of students obtaining any particular score. An NPR of 5 means that the student's score is within the lowest 5% of the national sample; an NPR of 95 means that the student's score is within the highest 5% of the national sample; an NPR of 50 is average.

Explaining National Percentile Ranking



The **Stanine (ST)** places the student's score on a scale of 1 (low) to 9 (high) and offers a broad overview of his or her performance.



The **Group Rank (GR)** shows how each student has performed in comparison to those in the defined group, such as the class or year group. The symbol '=' represents joint ranking with one or more other students.

Performance on a test like *CAT4* can be influenced by a number of factors, and the **confidence band** is an indication of the range within which a student's score lies. The narrower the band, the more reliable the score. This means that a 90% confidence band is a very high-level estimate. The dot represents the student's SAS and the horizontal line represents the confidence band. The yellow shaded area shows the **average score range**.

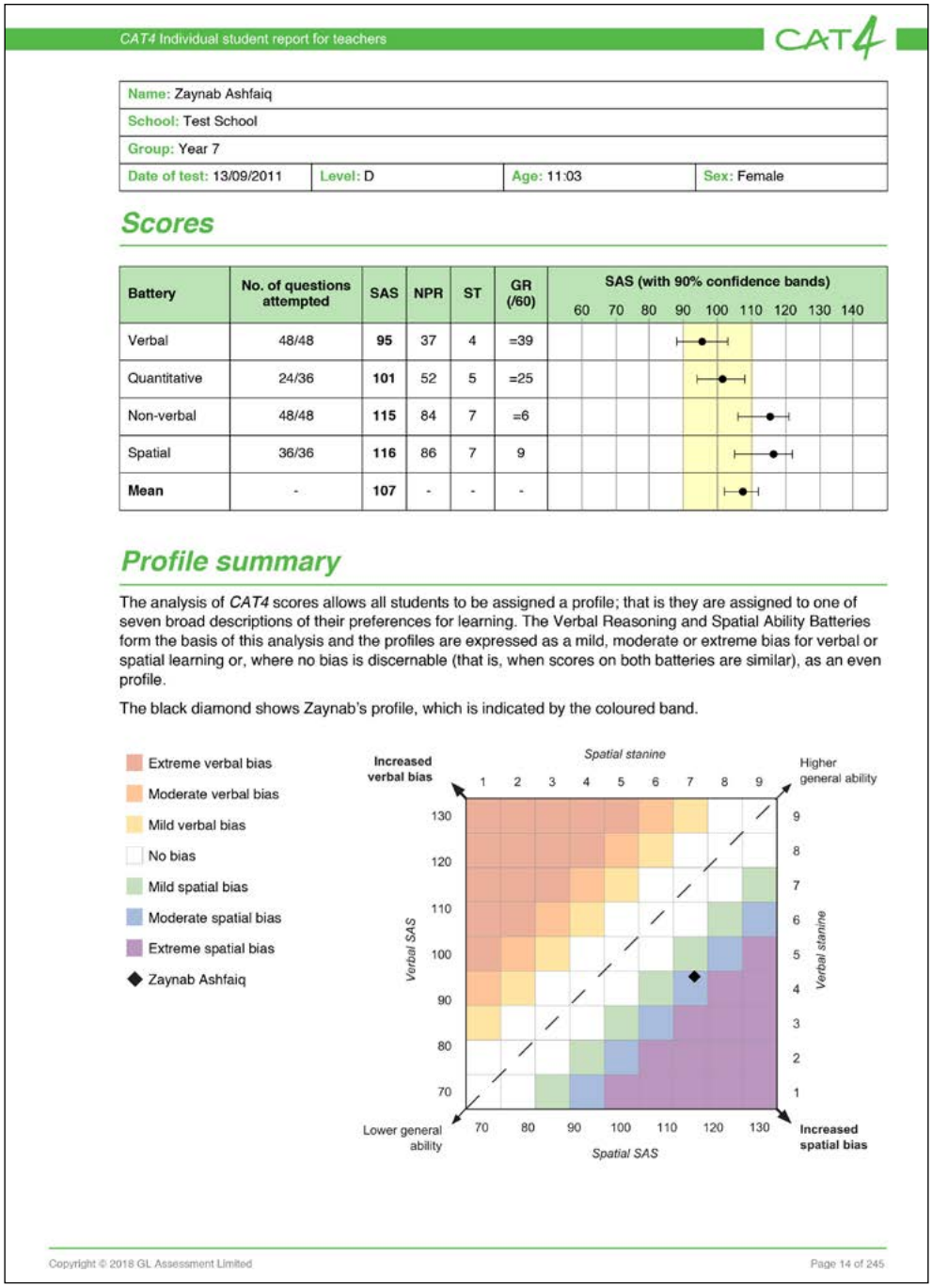
For *CAT4*, the confidence bands are typically plus or minus five standard score points around the student's actual SAS. These confidence bands are important in order to prevent us from over-interpreting small differences in scores. For example, if a student scored 95, and was retested some months later and scored 98, the second score is well within the confidence band for the first score and so does not represent a significant change. The confidence bands are also important when it comes to identifying significant differences between a student's scores on the four batteries. However, they vary depending on the *CAT4* level taken, the particular battery and the absolute level of the score. For example, the confidence bands for high

and low scores will tend to be wider where they are going towards the national mean (100).

The **number of questions attempted** can be important: a student may have worked very slowly (but accurately) and not finished the test and this will impact on his or her results.

An example *CAT4* Individual report

The report shows the level of scores in each battery. In *CAT4*, battery is the title given to each of the four pairs of tests which assess different aspects of ability (see pages 5-6). An example is given below.



CAT4 Individual student report for teachers

CAT4

Name: Zaynab Ashfaiq			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	Level: D	Age: 11:03	Sex: Female

Scores

Battery	No. of questions attempted	SAS	NPR	ST	GR (/60)	SAS (with 90% confidence bands) 60 70 80 90 100 110 120 130 140
Verbal	48/48	**95**	37	4	=39	
Quantitative	24/36	**101**	52	5	=25	
Non-verbal	48/48	**115**	84	7	=6	
Spatial	36/36	**116**	86	7	9	
Mean	-	**107**	-	-	-	

Profile summary

The analysis of *CAT4* scores allows all students to be assigned a profile; that is they are assigned to one of seven broad descriptions of their preferences for learning. The Verbal Reasoning and Spatial Ability Batteries form the basis of this analysis and the profiles are expressed as a mild, moderate or extreme bias for verbal or spatial learning or, where no bias is discernable (that is, when scores on both batteries are similar), as an even profile.

The black diamond shows Zaynab's profile, which is indicated by the coloured band.

Extreme verbal bias
Moderate verbal bias
Mild verbal bias
No bias
Mild spatial bias
Moderate spatial bias
Extreme spatial bias
Zaynab Ashfaiq

Increased verbal bias
Higher general ability
Spatial stanine
1 2 3 4 5 6 7 8 9
130 120 110 100 90 80 70
Verbal SAS
Verbal stanine
9 8 7 6 5 4 3 2 1
Lower general ability
70 80 90 100 110 120 130
Spatial SAS
Increased spatial bias

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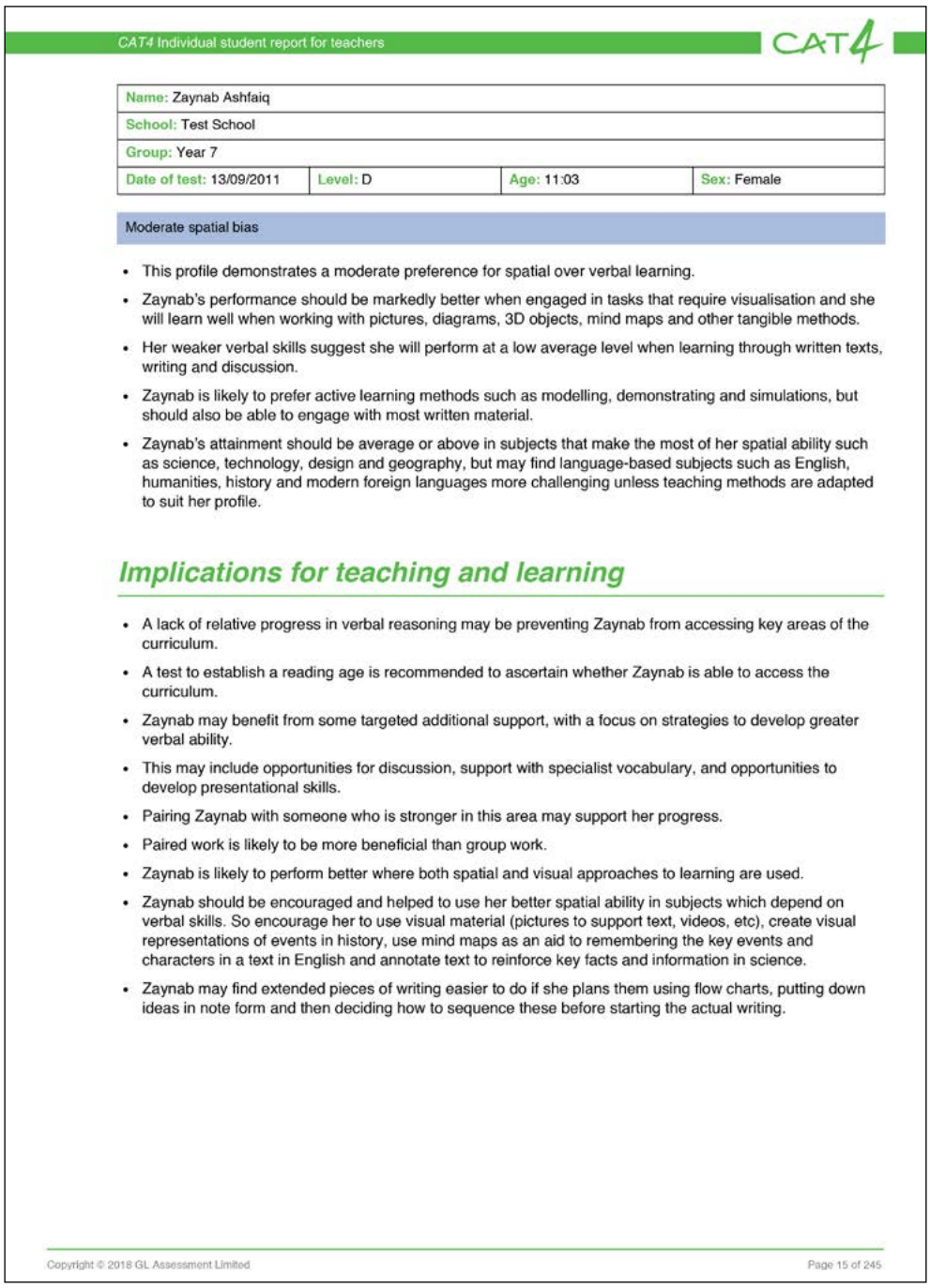


CAT4 Individual student report for teachers

CAT4

Name: Zaynab Ashfaiq			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	Level: D	Age: 11:03	Sex: Female

Moderate spatial bias

- This profile demonstrates a moderate preference for spatial over verbal learning.
- Zaynab's performance should be markedly better when engaged in tasks that require visualisation and she will learn well when working with pictures, diagrams, 3D objects, mind maps and other tangible methods.
- Her weaker verbal skills suggest she will perform at a low average level when learning through written texts, writing and discussion.
- Zaynab is likely to prefer active learning methods such as modelling, demonstrating and simulations, but should also be able to engage with most written material.
- Zaynab's attainment should be average or above in subjects that make the most of her spatial ability such as science, technology, design and geography, but may find language-based subjects such as English, humanities, history and modern foreign languages more challenging unless teaching methods are adapted to suit her profile.

Implications for teaching and learning

- A lack of relative progress in verbal reasoning may be preventing Zaynab from accessing key areas of the curriculum.
- A test to establish a reading age is recommended to ascertain whether Zaynab is able to access the curriculum.
- Zaynab may benefit from some targeted additional support, with a focus on strategies to develop greater verbal ability.
- This may include opportunities for discussion, support with specialist vocabulary, and opportunities to develop presentational skills.
- Pairing Zaynab with someone who is stronger in this area may support her progress.
- Paired work is likely to be more beneficial than group work.
- Zaynab is likely to perform better where both spatial and visual approaches to learning are used.
- Zaynab should be encouraged and helped to use her better spatial ability in subjects which depend on verbal skills. So encourage her to use visual material (pictures to support text, videos, etc), create visual representations of events in history, use mind maps as an aid to remembering the key events and characters in a text in English and annotate text to reinforce key facts and information in science.
- Zaynab may find extended pieces of writing easier to do if she plans them using flow charts, putting down ideas in note form and then deciding how to sequence these before starting the actual writing.

The profile for Zaynab Ashfaiq shows the number of questions attempted for each battery, her standard age score (SAS), national percentile rank, stanine and group rank for each battery. Zaynab's SAS are 95, 101, 115 and 116 respectively for each battery, placing her in stanines 4, 5, 7 and 7, and at the 37th, 52nd, 84th and 86th percentiles respectively. Zaynab attempted all of the 48 verbal questions, 24 of the 36 quantitative questions, all of the 48 non-verbal questions and all of the 36 spatial questions.

The row of text beneath the four sets of battery scores gives the student's **mean *CAT4* score**: in this case, 107. This is derived by summing the student's scores over all four batteries taken and dividing by the number of batteries taken – that is, (95 + 101 + 115 + 116) / 4 = 107.

The report also presents the SAS in a graphical format on a scale ranging from 60 to 140. The student's actual SAS is indicated by a black dot.

There is a horizontal line either side of the SAS dot, which indicates the 90% **confidence band**. Any test score is generated from a performance on a particular day. We know that *CAT4* is a highly reliable test, but nevertheless we can expect scores to fluctuate or change to some extent due to chance factors. The confidence band indicates the range in which a student's score would be expected to fall on 9 out of 10 test occasions.

Analysing *CAT4* profiles

CAT4 Individual reports also assign to the set of results one of **seven** broad descriptions of the student's abilities, as well as populating a narrative which provides:

- For teachers: a summary of the student's likely strengths and weaknesses, and **implications for teaching and learning**.
- For students: a summary and a set of probing questions and suggestions.
- For parents: a set of suggestions for what this means for the student.

The Verbal Reasoning and Spatial Ability Batteries form the basis of this analysis and the profiles are expressed as either mild, moderate or extreme bias for verbal or spatial learning, or, where no bias is discernible (that is, when the scores from both batteries are similar), an even profile across the two batteries.

The seven broad descriptions of ability are:

- Extreme verbal bias
- Moderate verbal bias
- Mild verbal bias
- No bias
- Mild spatial bias
- Moderate spatial bias
- Extreme spatial bias.

The most common profile for students to receive is the 'no bias' profile, since abilities in verbal and spatial are correlated to a surprisingly high degree. That is to say that students who score well on the Verbal Reasoning Battery are likely to perform well on the Spatial Ability Battery, and students who perform less well on one are likely to perform less well on the other.

Students also tend to move to a less extreme profile over time. Data from students who take *CAT4* twice, two years apart, suggest that students are unlikely to retain the same profile over this time period unless it is the 'no bias' profile.

This is consistent with other tests of cognitive ability, not just *CAT4*, and is part of the reason why contrasting results across batteries, and asking questions about one's understanding of the student, is so informative because differences are so unexpected.

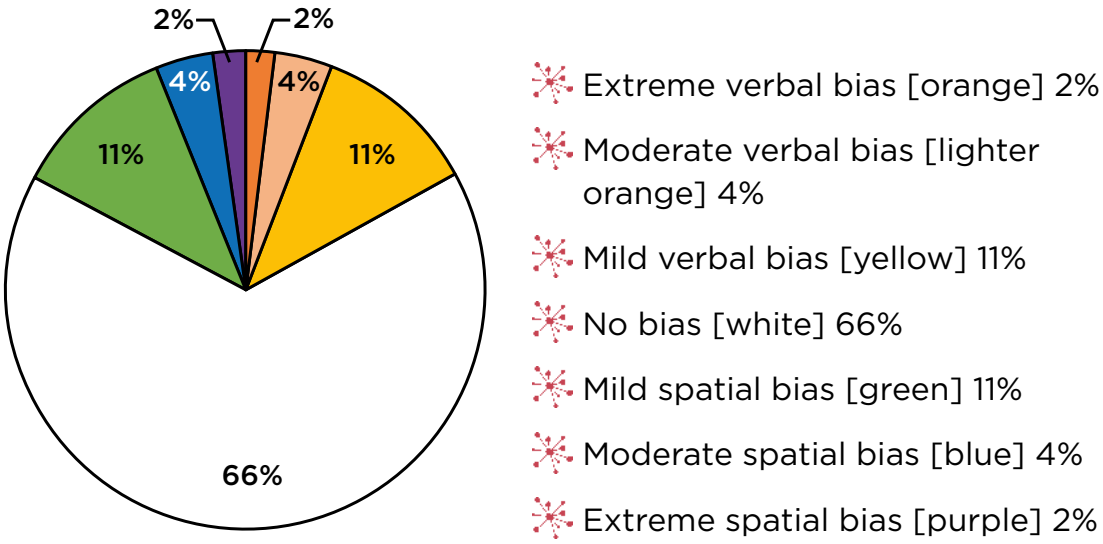


Figure 3 Breakdown of bias profiles

The **implications of the student's profile for teaching and learning** will depend on both the pattern of scores (strengths and weaknesses) and the overall level of the student's scores (relative to the average or expected score). An estimate of the overall level is captured by the mean *CAT4* score. In general, the mean *CAT4* score carries:

- the most information for no bias;
- less information for profiles with moderate and mild bias;
- still less information for profiles with extreme bias.

Therefore, when the teacher is asked to consider the overall level of scores, the mean *CAT4* score will provide only a rough guide. For profiles with extreme bias in particular, you should consider the level of the scores on the individual battery or batteries most relevant for

the profile. This is particularly true in circumstances when the student's level of English language proficiency might be affecting one battery more than another (see page 79).

In the group reports, each student's results are plotted as a point on a two-dimensional grid, with spatial SAS and stanine running horizontally left to right, and verbal SAS and stanine running vertically bottom to top. Each profile is displayed as a coloured area of the resulting grid, with a dashed line going through the diagonal representing absolutely no bias between the two abilities.

Students' results are plotted in this grid as dots, which display each set of results in proportion to their results and to the grid.

Assessment Insights support

If you have a question about *CAT4* data or your *CAT4* results, please contact our Assessment Insights team at Assessment.Insights@gl-assessment.co.uk. Our Assessment Insights team are assessment data experts with over 35 years combined classroom experience, here to help you make the best use of your data to inform in-school actions. You are also welcome to book a free one-to-one data consultation where the team will review your data in advance, provide an objective summary of key findings and help you to identify next steps.

Examples of the types of score profile

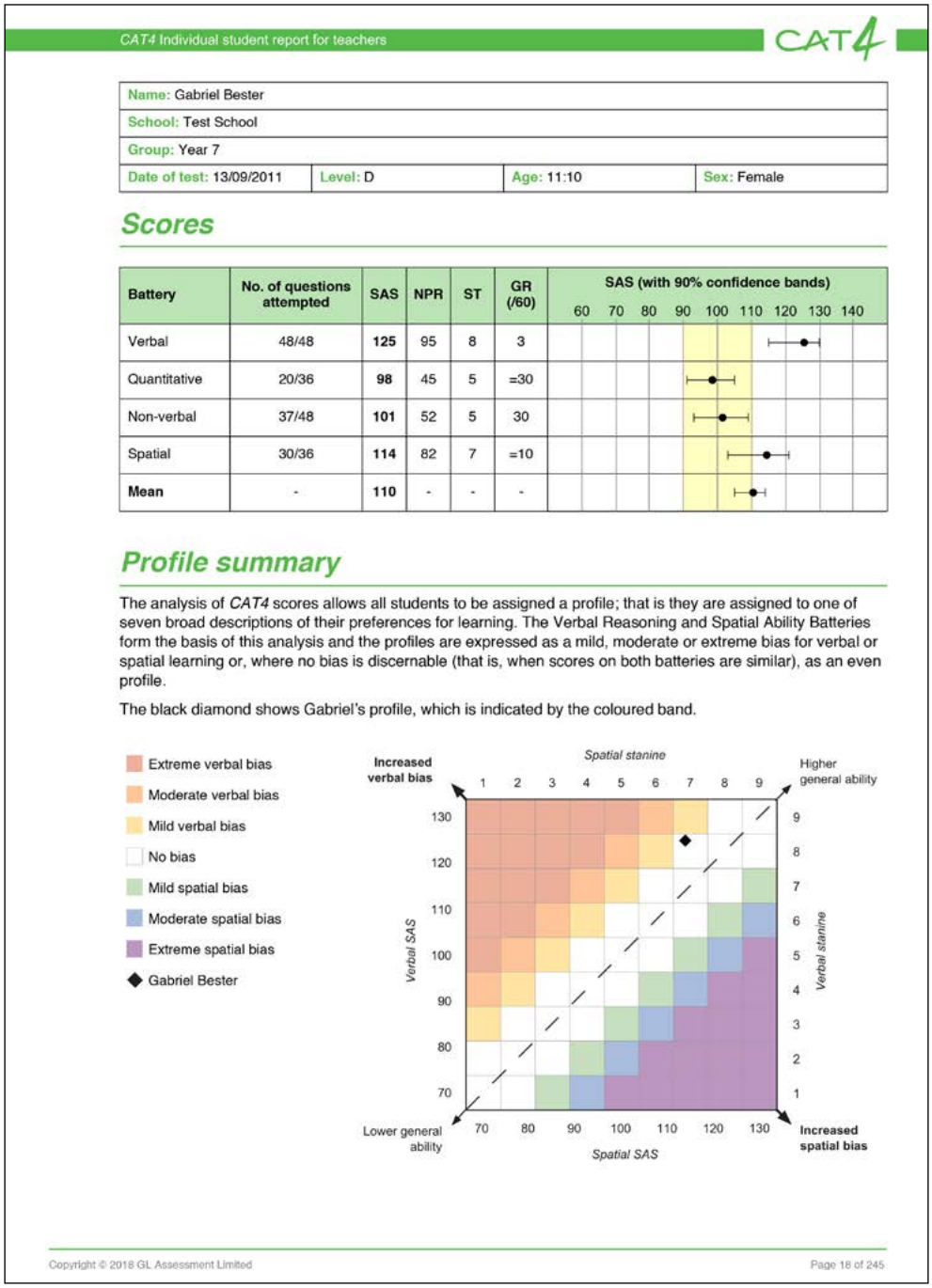
The types of profile are now described in greater detail with examples of each. These indicate some of the typical characteristics of students with such profiles. The examples discussed relate to students assessed shortly after entering secondary school.

No bias profiles

About two-thirds of students (66%) have no bias profiles. In a no bias profile, the student's results from the Verbal and Spatial Batteries are less than two stanines apart. There is only one general piece of information provided by the test, and that is the overall level, which will be well summarised by the mean *CAT4* score. For this reason, we can divide the profile up into above average, average, and below average cognitive abilities.

Example of an above average no bias profile

This example shows that Gabriel Bester has scores that are **average or above average** (stanines 5, 7 and 8) in all four batteries, and the overlapping confidence bands for the four batteries indicate an even or no bias profile of above average scores. It is important that students like Gabriel are identified at the earliest possible opportunity upon entering the school. These students are likely to become bored or disaffected if not given sufficiently challenging or engaging work. Expectations for their attainment across the curriculum need to be appropriately high.



CAT4 Individual student report for teachers

CAT4

Name: Gabriel Bester			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	**Level:** D	**Age:** 11:10	**Sex:** Female

Scores

Battery	No. of questions attempted	SAS	NPR	ST	GR (/60)	SAS (with 90% confidence bands) 60 70 80 90 100 110 120 130 140
Verbal	48/48	**125**	95	8	3	
Quantitative	20/36	**98**	45	5	=30	
Non-verbal	37/48	**101**	52	5	30	
Spatial	30/36	**114**	82	7	=10	
Mean	-	**110**	-	-	-	

Profile summary

The analysis of *CAT4* scores allows all students to be assigned a profile; that is they are assigned to one of seven broad descriptions of their preferences for learning. The Verbal Reasoning and Spatial Ability Batteries form the basis of this analysis and the profiles are expressed as a mild, moderate or extreme bias for verbal or spatial learning or, where no bias is discernable (that is, when scores on both batteries are similar), as an even profile.

The black diamond shows Gabriel's profile, which is indicated by the coloured band.

Extreme verbal bias
Moderate verbal bias
Mild verbal bias
No bias
Mild spatial bias
Moderate spatial bias
Extreme spatial bias
Gabriel Bester

Spatial stanine
Increased verbal bias
Higher general ability
Verbal SAS
Verbal stanine
Lower general ability
Increased spatial bias
Spatial SAS

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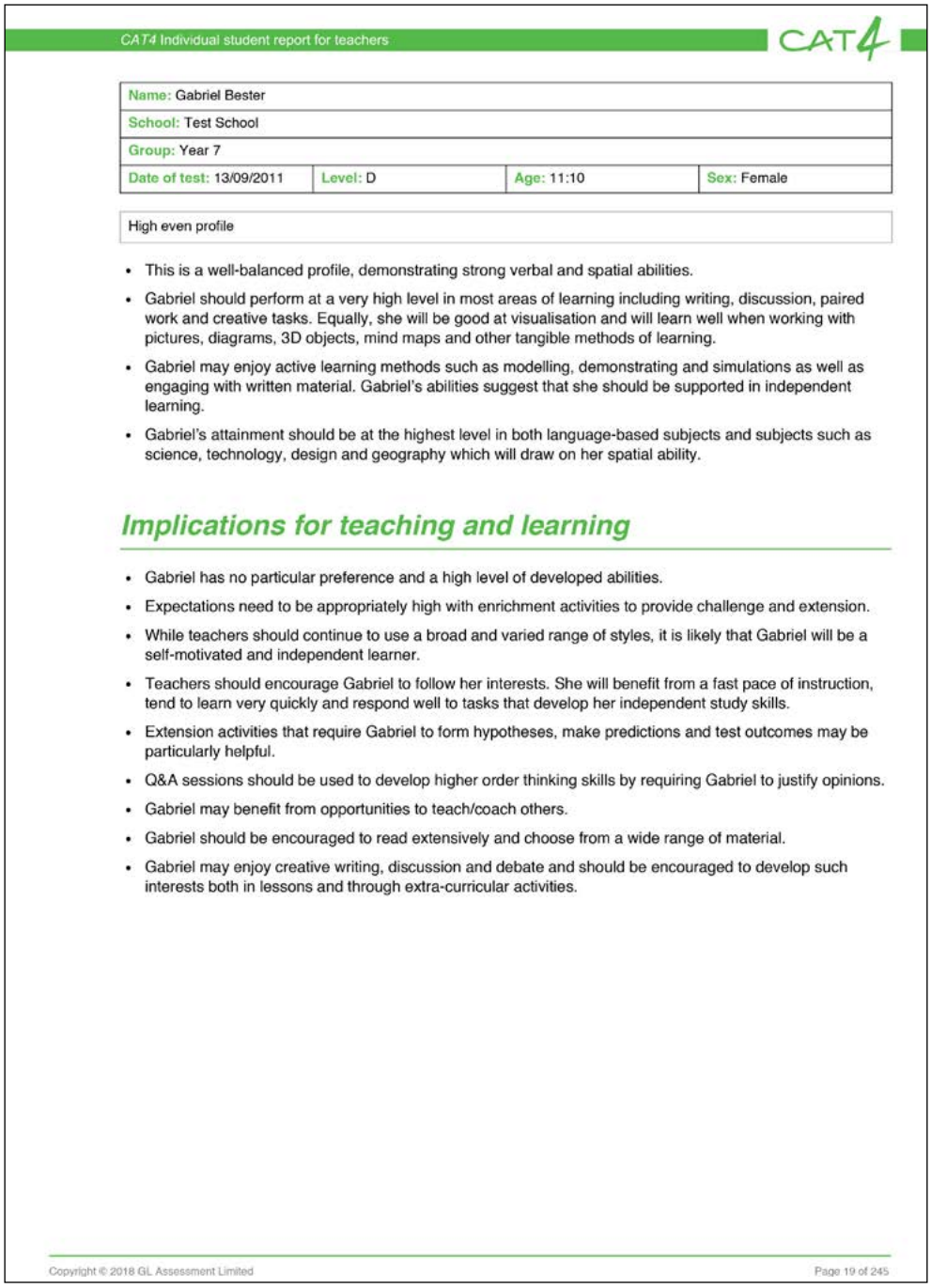


CAT4 Individual student report for teachers

CAT4

Name: Gabriel Bester			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	**Level:** D	**Age:** 11:10	**Sex:** Female

High even profile

- This is a well-balanced profile, demonstrating strong verbal and spatial abilities.
- Gabriel should perform at a very high level in most areas of learning including writing, discussion, paired work and creative tasks. Equally, she will be good at visualisation and will learn well when working with pictures, diagrams, 3D objects, mind maps and other tangible methods of learning.
- Gabriel may enjoy active learning methods such as modelling, demonstrating and simulations as well as engaging with written material. Gabriel's abilities suggest that she should be supported in independent learning.
- Gabriel's attainment should be at the highest level in both language-based subjects and subjects such as science, technology, design and geography which will draw on her spatial ability.

Implications for teaching and learning

- Gabriel has no particular preference and a high level of developed abilities.
- Expectations need to be appropriately high with enrichment activities to provide challenge and extension.
- While teachers should continue to use a broad and varied range of styles, it is likely that Gabriel will be a self-motivated and independent learner.
- Teachers should encourage Gabriel to follow her interests. She will benefit from a fast pace of instruction, tend to learn very quickly and respond well to tasks that develop her independent study skills.
- Extension activities that require Gabriel to form hypotheses, make predictions and test outcomes may be particularly helpful.
- Q&A sessions should be used to develop higher order thinking skills by requiring Gabriel to justify opinions.
- Gabriel may benefit from opportunities to teach/coach others.
- Gabriel should be encouraged to read extensively and choose from a wide range of material.
- Gabriel may enjoy creative writing, discussion and debate and should be encouraged to develop such interests both in lessons and through extra-curricular activities.

- This is a **balanced profile** with no bias, demonstrating strong verbal and spatial abilities.
- The student should perform at a **very high level** in most areas of learning, including writing, discussion, paired work and creative tasks. Equally, they are likely to be good at visualisation and should learn well when working with pictures, diagrams, 3D objects, mind maps and other tangible methods of learning.
- The student may enjoy active learning methods such as modelling, demonstrating and simulating, as well as engaging with stimulating written material.
- The student is likely to enjoy alternative ways of completing a task, and teachers should provide the opportunity for a student to present their learning in different ways that still address the identified criteria.
- The student's abilities suggest that they should be supported in developing their independent learning skills to ensure that achievement matches potential.
- The student's attainment should be at a high level in both language-based subjects and subjects such as science, technology, design and geography which will draw on their spatial ability. Where this is not supported by appropriate data, teachers should identify why achievement does not appear to match potential and use the approaches described in this resource to stimulate, enrich and extend the learning.

What does this look like in the classroom?

Students with above average and unbiased cognitive abilities are usually **self-motivated and independent learners**.

- They tend to learn very quickly and need very little practice to gain competence in a new skill.
- They benefit from a fast pace of instruction.
- They will be good at asking questions, forming hypotheses, predicting and applying examples to new situations.
- They are most engaged when allowed to discover relationships themselves using 'guided discovery' approaches.
- Teachers should encourage them to follow their interests and enable them to develop independent study skills such as use of the library, the internet and other resources.

However, such students **need to be challenged, inspired and motivated** with materials, projects and problems that are more demanding than those used for typical students. If this does not happen, there is the danger that these students become part of what has been called the 'quietly disaffected' – that is, able students who do not realise their potential because they are insufficiently challenged.

In their 2015 report, the UK school inspection body, Ofsted, indicated that many of the most able students were not routinely getting the information, advice and guidance they needed to develop a self-assured approach to preparing for their future studies or their next steps into employment or training, and that this situation had not changed since the previous report published two years earlier.

Extension work that specifically develops deeper thinking will provide opportunities for a greater challenge. Above-average students generally enjoy group work and are valuable group members.

- They can learn well both in groups with other able peers, through an additional element of challenge, and in mixed-ability groups, where they can help to explain, summarise discussions and model higher-order thinking skills for other students.

Throughout the learning process, it is important that teachers develop high expectations of such students but continue to provide support and encouragement along with the challenge to achieve.

There are two ways to interpret the phrase 'stretch and challenge'. On the one hand, it relates to whole-class teaching and the importance of stretching and challenging every pupil's thinking. On the other, it relates to individuals and the importance of pushing the thinking of the most able pupils. Both interpretations are equally valid and essential components of great teaching.

Gershon (2019)

High-achieving, no bias learners often share common characteristics that can be systematically developed at a whole-school and individual-teacher level through content (what is taught) and process (how it is taught).

- These characteristics include a sense of self-awareness about personal learning attributes, a high level of fluency in literacy and numeracy, good critical-thinking skills, well-developed social skills and effective speaking and listening skills.
- Teachers can further encourage the development of curricular breadth (linking learning to real-world situations) and curricular depth (going beyond syllabus requirements) in a high-challenge, low-stress learning environment.
- Students may benefit from opportunities to teach or coach others.

Many schools use *CAT4* as part of their process for identifying **gifted** students. *CAT4* is frequently used because a focus on reasoning ability can identify students who may not be found through an analysis of purely curriculum-related attainments. *CAT4* can also provide a measure of the student's abilities against a national sample, not just in relation to his or her peers within the school. For example, we can see that, in comparison with the UK norm group, Gabriel **is in the top 7%** of his age group on the verbal reasoning score and in the top 11% on the non-verbal reasoning and spatial scores. Based on this, it is very likely that Gabriel would be identified as **gifted**.

For the extremely high-scoring student, a score in stanine 9 (an SAS of 127 or above and in the top 4% of the age group) on any one of the four *CAT4* batteries provides evidence to suggest that the student is gifted.

Examples of strategies for an above average no bias profile

It is important that teachers recognise the special needs of gifted students and understand that specific support is required to ensure that their potential is realised. Their ability may give the impression that they are self-sufficient and do not need teacher support, but focused challenge at an appropriate level is essential if such students are to avoid becoming bored or even disaffected. Teachers should be mindful that gifted students may even be isolated or misunderstood by their peers.

In the classroom, these students will frequently finish work more quickly than their peers. Accordingly, teachers must engage students in more challenging learning activities. These can focus on deepening knowledge in the subject area that peers are working on, or on developing and supporting special areas of interest the student may have. It is important that students are not simply doing work that is 'more of the same' as this is a quick route toward boredom or disaffection. **Extension menus** and **independent study projects** are two ways to accomplish this goal, while allowing the student some control over their work.

1. Extension menus

Extension menus offer choices in the way that students demonstrate their understanding and can include a range of different options. Students may be able to select from a set of assignments, with each offering objectives depending on their *CAT4* profile. This option allows students to show their learning in a more challenging mode than they might be used to.

2. Independent study

Independent study projects offer a further level of independence. It is essential that such projects are investigative activities and artistic productions in which the learner assumes the role of a first-hand inquirer: thinking, feeling and acting like a practising professional.

Independent study projects need to be carefully planned. Teachers could adopt the Enrichment Triad Model (developed by Renzulli and Reis, 1991) and provide extension activities in three distinct tiers:

- general exploratory activities, in which students are introduced to a variety of topics and interest areas;
- group training activities which develop creativity and research skills;
- investigations of real-world situations or problems of personal interest to the student.

In all independent study models, it is important for teachers to provide a structure that includes a careful balance between initial teacher direction and subsequent student self-directed inquiry.

These models usually involve a student focus on developing skills and attitudes that promote an understanding of the value of lifelong autonomous learning. They may also include presentations to both small and large groups with students being encouraged to develop an awareness of the needs of different audiences.

It is important that, in both extension menus and independent study projects, teachers are seen to value the student activity rather than present it as simply additional work for 'finishing first' or 'being clever' (Table 1).

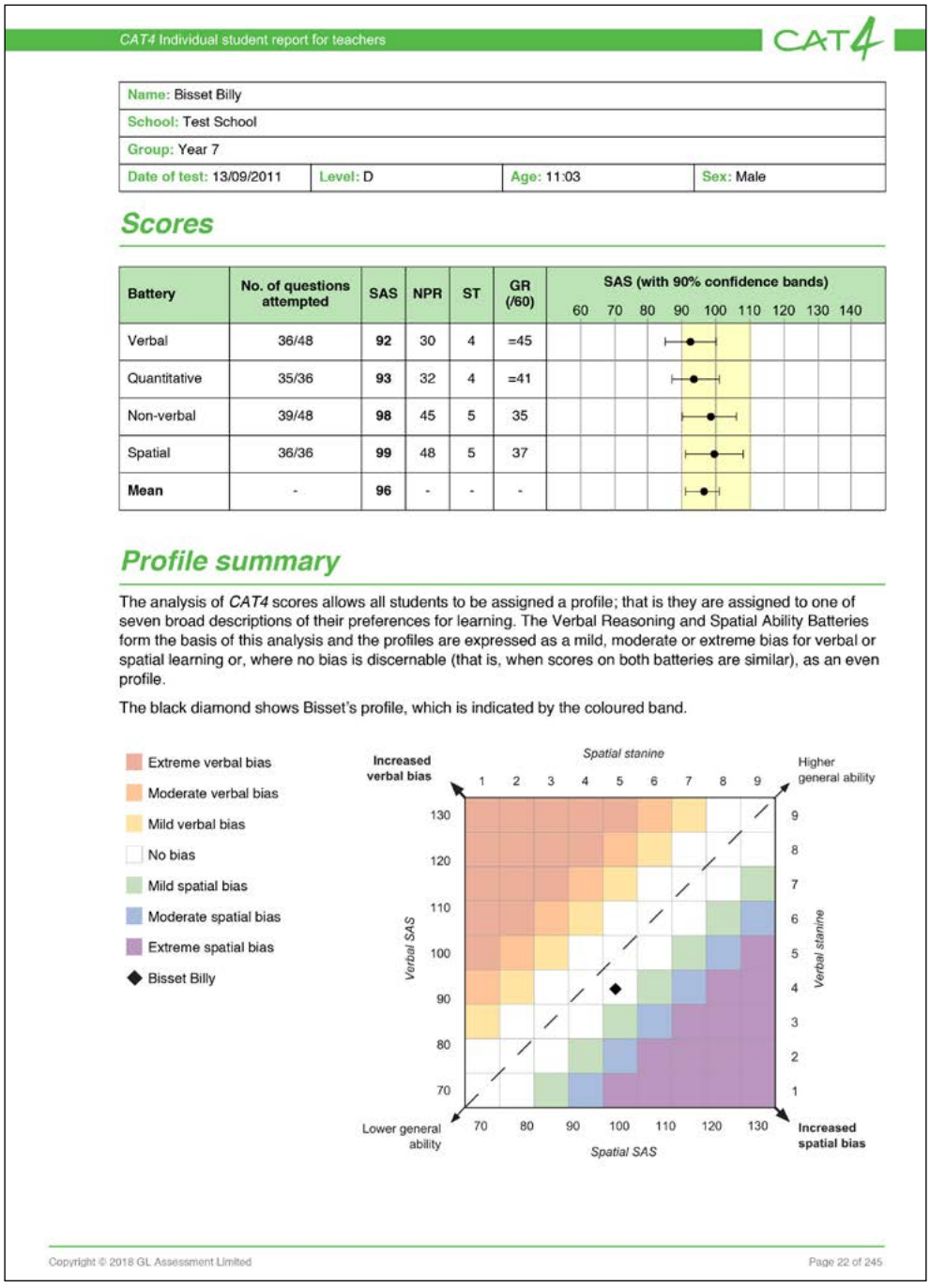
Table 1. Examples of specific activities for different subject areas

	Extension activities	Independent study projects
Ages 5-8		
Languages	Play games that develop early critical-thinking skills (for example, *You Can't Take Me!* in which children have to justify keeping objects that the teacher wants to throw away).	Create a café role-play environment to explore learning a range of new language words and phrases (for example, French, Spanish or Chinese).
Mathematics	Encourage alternative ways to solve the same simple calculation.	Use maths as part of a classroom culture that support problem solving in all subjects - for example using guidance and practical activities from the nrich project: https://nrich.maths.org/10334
Science	Use a concept cartoon challenge to present a scientific problem (for example, will a snowman wearing a coat melt more quickly or more slowly than one without a coat?).	Use free online resources to design a spacesuit and find out how an astronaut feels when wearing one (for example, https://www.tes.com/teaching-resource/principia-space-diary-design-your-space-suit-for-ks1-ks2-p2-7-y1-6-11461467).
Humanities and Arts	Water drop art: create dramatic artworks and explore surface tension using waxed paper and coloured water.	Develop a walk-through-time project in which children use interview, archive material and realia to create a visual walk through their family history.
Ages 9-13		
Languages	Devise a PowerPoint presentation on a chosen fiction text studied in English.	Use an online language programme such as http://www.onestopenglish.com/teenagers/a-time-to-travel/brazil-lost-in-the-rainforest/ to model the creation of an audio EAL support file.
Mathematics	Use maths challenge sites such as https://parallel.org.uk/ to provide a wide range of extension activities.	Create a maths trail for younger learners using a template and guidance notes.
Science	Challenge students to create a scientific model (for example, a cell, a heart or a battery) out of everyday materials.	Use the resources at https://www.arkive.org/education/teaching-resources-11-14 to explore change, using a classroom presentation, teacher notes and activity cards to support the project.
Humanities and Arts	Research and give a presentation on a specific historical event linked to curriculum study in history or geography (for example, the eruption of Krakatoa).	Choose an artwork (for example, a painting, music or dance) and research the links between the artwork and its historical context.

	Extension activities	Independent study projects
Ages 14-16		
Languages	Research, create and give a drama-based scenario presentation on a literacy character currently being studied.	Explore the language development opportunities in a PGL Leadership Course (https://create.arduino.cc/projecthub/JulienChateau/spideruino-5915e9?ref=tag&ref_id=lego&offset=0).
Mathematics	Ask students *Why?* and *What if...?* to generate deeper thinking, before giving extension activities such as solving magic square problems.	Undertake an Extended Project Qualification (EPQ). Students follow an individual research project on a topic of their choice and receive an internationally recognised qualification on completion. Projects can be multidisciplinary and can allow students to further their interest in STEM and gain experience of extended practical work.
Science	Explore the Arduino Hub and identify Lego projects that students could undertake independently (for example, making a robotic arachnid https://create.arduino.cc/projecthub/JulienChateau/spideruino-5915e9?ref=tag&ref_id=lego&offset=0).	Explore the range of real-world STEM projects from UK-based Crest Awards (https://www.crestawards.org/).
Humanities and Arts	Explore the Doodle for Google site and encourage students to research and then develop a Google doodle to be entered in competition (https://doodles.google.com/d4g/).	Use NMUN to provide students with a forum to hone skills in diplomacy, negotiation, critical thinking, compromise, public speaking, writing and research (https://www.nmun.org/).

Example of an average no bias profile

This example shows the profile for Bisset Billy for whom all four scores are **average** (stanines 4, 5 and 6) and the overlapping confidence bands for the four batteries indicate an even profile of average scores. Bisset has standard age scores of 92, 93, 98 and 99 on the Verbal, Quantitative, Non-verbal and Spatial Batteries respectively, placing him in stanine 4 or 5 on each battery.



CAT4 Individual student report for teachers

CAT4

Name: Bisset Billy			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	Level: D	Age: 11:03	Sex: Male

Scores

Battery	No. of questions attempted	SAS	NPR	ST	GR (/60)	SAS (with 90% confidence bands) 60 70 80 90 100 110 120 130 140
Verbal	36/48	**92**	30	4	=45	
Quantitative	35/36	**93**	32	4	=41	
Non-verbal	39/48	**98**	45	5	35	
Spatial	36/36	**99**	48	5	37	
Mean	-	**96**	-	-	-	

Profile summary

The analysis of *CAT4* scores allows all students to be assigned a profile; that is they are assigned to one of seven broad descriptions of their preferences for learning. The Verbal Reasoning and Spatial Ability Batteries form the basis of this analysis and the profiles are expressed as a mild, moderate or extreme bias for verbal or spatial learning or, where no bias is discernable (that is, when scores on both batteries are similar), as an even profile.

The black diamond shows Bisset's profile, which is indicated by the coloured band.

Extreme verbal bias
Moderate verbal bias
Mild verbal bias
No bias
Mild spatial bias
Moderate spatial bias
Extreme spatial bias
Bisset Billy

Increased verbal bias
Spatial stanine
Higher general ability
Verbal SAS
Verbal stanine
Lower general ability
Spatial SAS
Increased spatial bias

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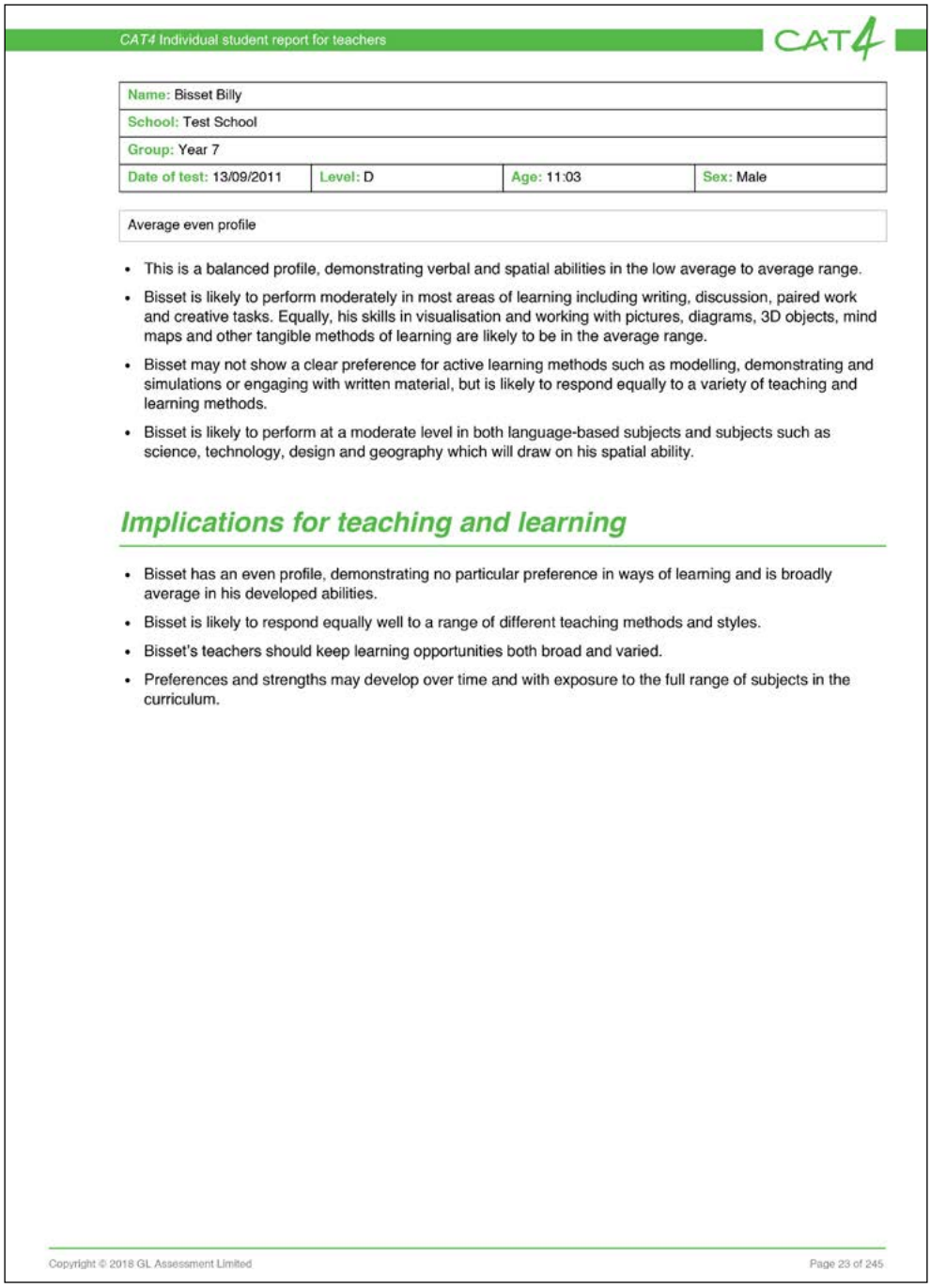


CAT4 Individual student report for teachers

CAT4

Name: Bisset Billy			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	**Level:** D	**Age:** 11:03	**Sex:** Male

Average even profile

- This is a balanced profile, demonstrating verbal and spatial abilities in the low average to average range.
- Bisset is likely to perform moderately in most areas of learning including writing, discussion, paired work and creative tasks. Equally, his skills in visualisation and working with pictures, diagrams, 3D objects, mind maps and other tangible methods of learning are likely to be in the average range.
- Bisset may not show a clear preference for active learning methods such as modelling, demonstrating and simulations or engaging with written material, but is likely to respond equally to a variety of teaching and learning methods.
- Bisset is likely to perform at a moderate level in both language-based subjects and subjects such as science, technology, design and geography which will draw on his spatial ability.

Implications for teaching and learning

- Bisset has an even profile, demonstrating no particular preference in ways of learning and is broadly average in his developed abilities.
- Bisset is likely to respond equally well to a range of different teaching methods and styles.
- Bisset's teachers should keep learning opportunities both broad and varied.
- Preferences and strengths may develop over time and with exposure to the full range of subjects in the curriculum.

This is a no bias profile, demonstrating verbal reasoning and spatial abilities in the **average** range.

- The student may achieve at an average level in most areas of learning, including writing, discussion, paired work and creative tasks, and the profile indicates similarly average skills in visualisation and working with pictures, diagrams, 3D objects, mind maps and other tangible methods of learning. However, teachers should ensure that high expectations, the sharing of clear learning intentions, the use of challenging questions and the creation of opportunities for the student to demonstrate their learning are all integral to the learning environment.
- The student may not show a clear preference for specific learning methods but will benefit from a variety of active teaching approaches such as modelling, demonstrating and the use of simulations.

What does this look like in the classroom?

It is important that teachers do not lower expectations for students with an average no bias profile. They should:

- Identify learning objectives that support all student aspirations. It is better that teachers do not 'differentiate' using the language of '**all** students, **most** students, **some** students', but instead provide one common objective, for example, *Describe and explain the way in which blood circulates around the human body*.
- Setting higher expectations across the board works positively for most students – 'a rising tide lifts all boats' – and helps to develop a culture of aspiration and an acceptance of challenge as part of the learning process.

> *Every class is a 'mixed-ability class'. There is always a range. … I've found that it is a win-win to cater explicitly for the highest attaining students in any group: to 'teach to the top', pitching every lesson and the general thrust of every unit of work to stretch them. In doing so everyone benefits.*
>
> Sherrington (2017)

Given that a significant number of students in any group will fall into the average-achieving no bias category, it is important that teachers use their classroom management skills to help raise the group level of achievement while paying close attention to the learning demands of all students in this category.

The effective teacher understands that scaffolding support for student learning is the gateway to achieving independent success, and examples of effective strategies are provided below.

Examples of strategies for an average no bias profile

Teachers should be focused on using strategies that encourage these students to move securely from guided practice to independent practice. The aim for average no bias profile students is to develop the independent learning skills that above average no bias profile students are already likely to possess.

One key finding from cognitive psychology is that subject experts approach a problem differently to non-experts. Experts are more able to discern pertinent information from the irrelevant information presented, which decreases the load on the working memory. They are more likely to select the most relevant process to solve a problem, and then attend to the degree of success from that process and change tactic when needed. Experts have better retention of new relevant information (these factors will be returned to in the section on metacognitive skills).

For example, experts in chess are very good at remembering arrangements of pieces on a chess board, but only when the arrangements are from a plausible game. When pieces are arranged implausibly or at random, chess experts have much less memory advantage over non-experts (Chase and Simon, 1973).

The relevance of these considerations for education has been covered by the National Research Council in *Knowing What Students Know: The Science and Design of Educational Assessment* (2001), which calls for a complete rethink to curricula and assessment in the USA, and leads to the formation of 'learning progressions' based curricula and schemes of work (Gallacher and Johnson, 2019). Even without a 'learning progression' based curriculum, the interplay between expertise and

skill learning will still be a relevant consideration for teachers. The strategies below cover related ideas about how expertise can be communicated to learners of average performance and no bias.

1. Scaffolding learning

The tasks and activities that students should be aiming for are what Vygotsky called the Zone of Proximal Development (ZPD). The ZPD is simply the difference between what a child can achieve independently and what can be achieved with the support of a more knowledgeable other (MKO). The MKO need not be a teacher – it could also be a fellow student or a carefully developed resource. This principle is often simply called 'scaffolding' and it is important that – as with the support provided for a new building under construction – the 'scaffolding' is removed once it is not needed. In this way, students can make progress through a series of clearly defined steps.

> *Every function in the child's cultural development appears twice: first on the social level and later on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory and to the formation of concepts. All the higher functions originate as actual relationships between individuals.*
>
> Vygotsky (1962)

A lot of the teaching strategies presented here build on the ideas of memory, expertise and 'scaffolding'. Readers who are particularly motivated to understand more about how these principles can be applied to develop thinking skills themselves are recommended to read the *Let's Think! Handbook: A Guide to Cognitive Acceleration in the Primary School*. Drawing on years of research into applying a family of cognitive intervention programmes, the handbook covers skills relevant to the primary curriculum in literacy, maths and science, using the material to develop general thinking skills.

2. Small-step learning

One key assumption of this approach to teaching a group of students is that the teacher has a clear understanding of the students' starting points. It is crucial for the teacher to know what the learners already know: their prior knowledge and skills.

Many teachers will know this strategy as part of a KWL activity: finding out what children **K**now, what they **W**ant to find out and, finally, identifying what they have **L**earned. Using a KWL grid in the classroom will give teachers a good idea of what is already known and provide a structure for students that shows where they are going in their learning journey. This, and other similar strategies such as quizzes at the start of a lesson, is an essential part of ensuring that the greatest number of students in any group have accessed and learned as much new knowledge and skills as possible.

The use of KWL grids has another key function in the learning process.

One of the lessons from cognitive psychology is the understanding that learning anything new is directly related to our ability to make connections with related previous learning. This goes back to our understanding of working memory (see page 10) that the memory system prefers a few chunks of information to lots of little bits of unrelated information.

Teachers, therefore, need to identify clear objectives for most activities that are designed to show new learning. In this way they will ensure that students have a clear end goal in mind. Hattie calls this "showing students what success looks like". What this looks like in the classroom will be demonstrated in the guidance for the below average no bias profile student, Elena Mazzoni (see page 38), and in the guidance for the relative weakness in the Quantitative Reasoning profile of Aelwyn Probert (see page 105).

Thinking carefully about the delivery strategies used in the classroom, teachers have to match the choice of activity with the intended outcome. Good teaching is not limited to one pedagogical approach: progressive or traditional, student-centred or teacher-led, enquiry learning or direct instruction. Indeed, there is a growing body of evidence that promotes the effectiveness of good, dynamic teacher instruction in the classroom, and the research of Rosenshine and others clearly illustrates this. Rosenshine's 10 key strategies are:

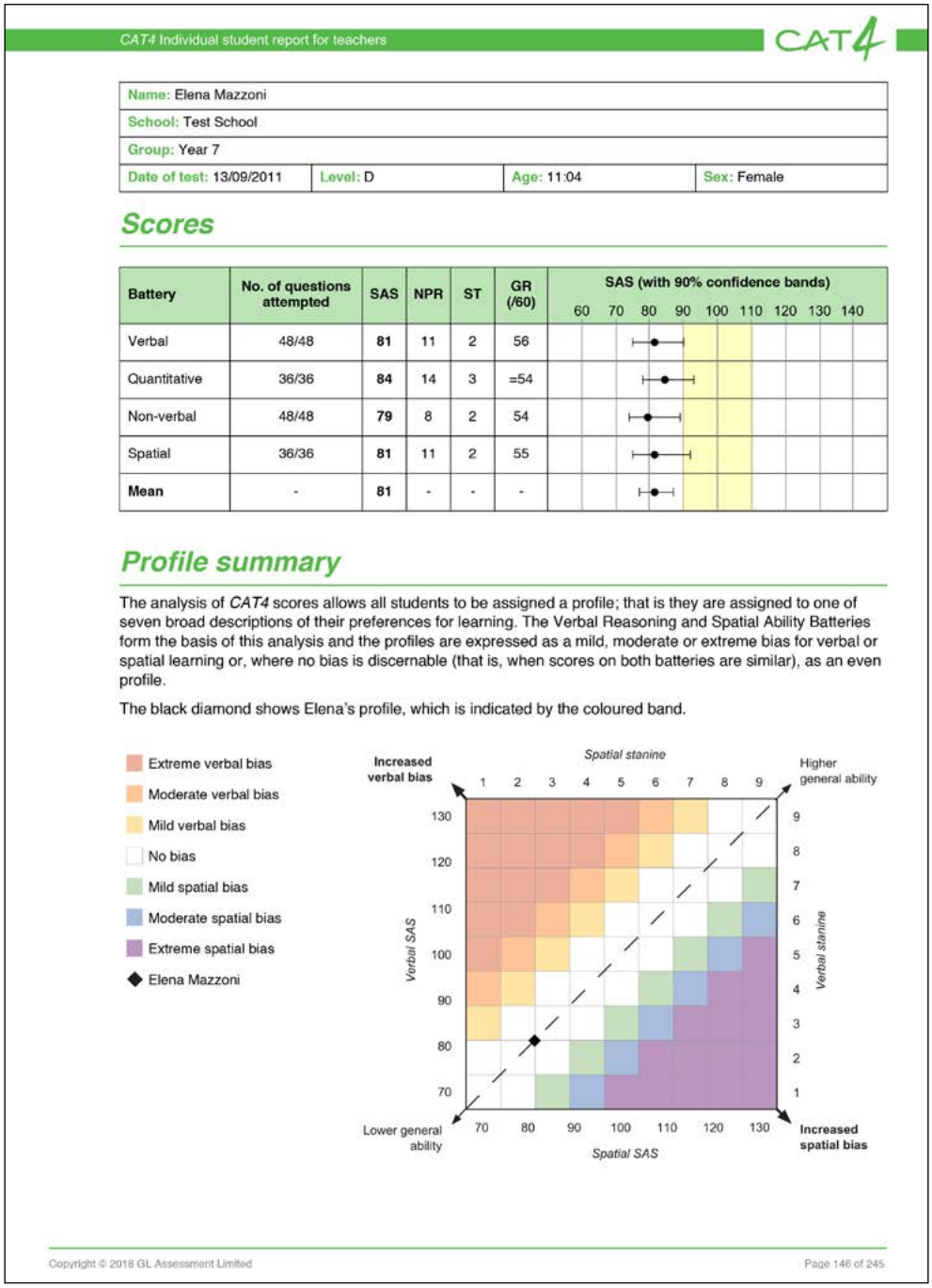
- Begin a lesson with a short review of previous learning
- Present new material in small steps with student practice after each step
- Ask a large number of questions and check the responses of all students
- Provide models
- Guide student practice
- Check for student understanding
- Obtain a high success rate
- Provide scaffolding for difficult tasks
- Require and monitor independent practice
- Engage students in weekly and monthly review

For further on modelling see page 62.

Much of this is not new and good teachers are likely be using these strategies in their classrooms. However, the systematic adoption of such practices will benefit all students' learning and help to support learning for the individual profiles identified in this document. Teachers will find references to many of these strategies in this profile guidance document. As a quick reference, the infographic representation of the 10 principles developed by Caviglioli (2016) is a very useful tool. It can be found here: https://teachinghow2s.com/blog/principles-of-instruction.

Example of a below average no bias profile

The profile for Elena Mazzoni shows all four scores **below average** (stanines 2 or 3). The overlapping confidence bands for the four batteries indicate an even profile of below average scores. Elena has SAS of 81, 84, 79 and 81 on the Verbal, Quantitative, Non-verbal and Spatial Batteries respectively, placing her in stanine 2 on each battery.



CAT4 Individual student report for teachers

CAT4

Name: Elena Mazzoni			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	Level: D	Age: 11:04	Sex: Female

Scores

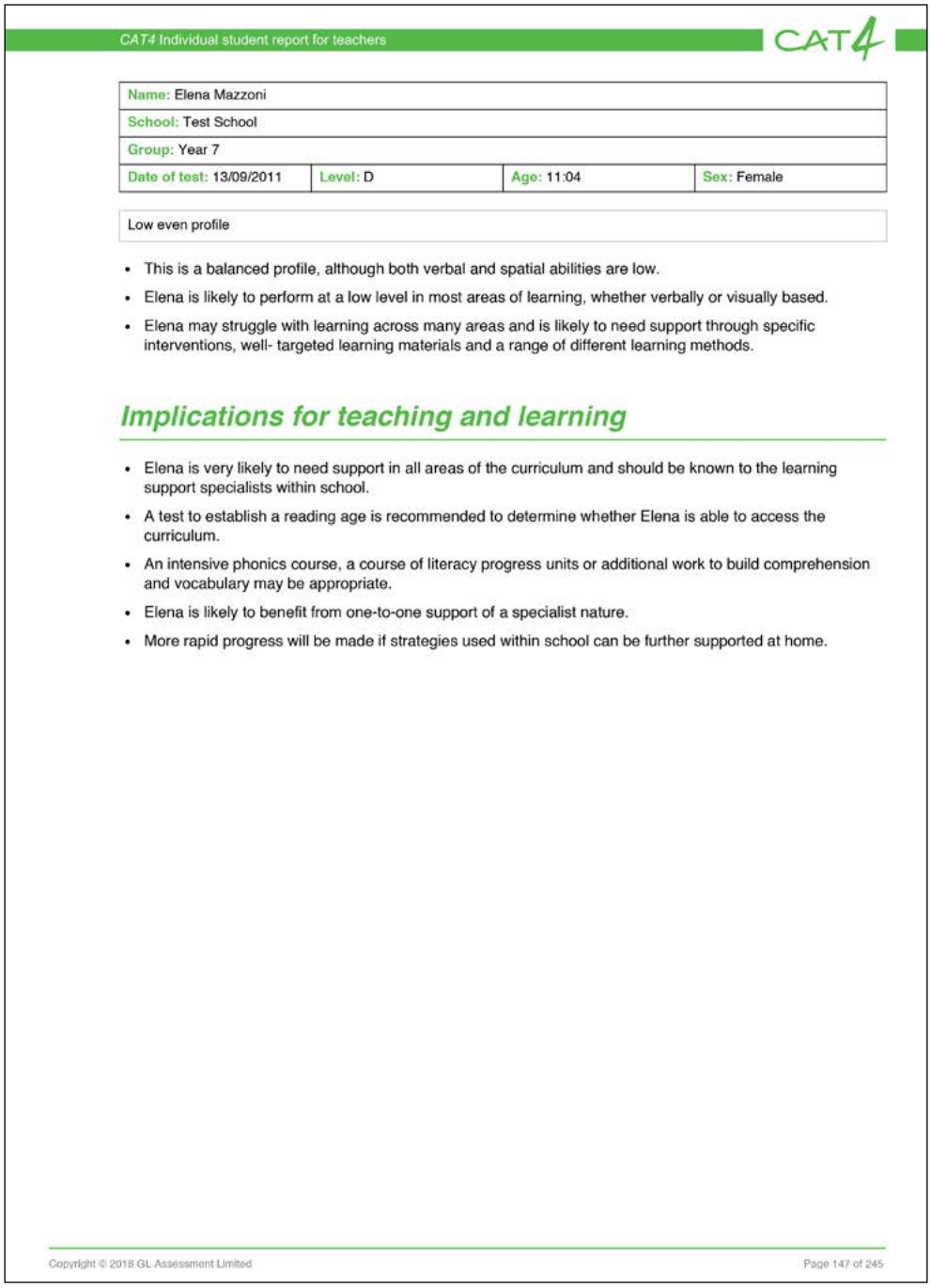
Battery	No. of questions attempted	SAS	NPR	ST	GR (/60)	SAS (with 90% confidence bands) 60 70 80 90 100 110 120 130 140
Verbal	48/48	**81**	11	2	56	
Quantitative	36/36	**84**	14	3	=54	
Non-verbal	48/48	**79**	8	2	54	
Spatial	36/36	**81**	11	2	55	
Mean	-	**81**	-	-	-	

Profile summary

The analysis of *CAT4* scores allows all students to be assigned a profile; that is they are assigned to one of seven broad descriptions of their preferences for learning. The Verbal Reasoning and Spatial Ability Batteries form the basis of this analysis and the profiles are expressed as a mild, moderate or extreme bias for verbal or spatial learning or, where no bias is discernable (that is, when scores on both batteries are similar), as an even profile.

The black diamond shows Elena's profile, which is indicated by the coloured band.

Extreme verbal bias
Moderate verbal bias
Mild verbal bias
No bias
Mild spatial bias
Moderate spatial bias
Extreme spatial bias
Elena Mazzoni



CAT4 Individual student report for teachers

CAT4

Name: Elena Mazzoni			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	**Level:** D	**Age:** 11:04	**Sex:** Female

Low even profile

- This is a balanced profile, although both verbal and spatial abilities are low.
- Elena is likely to perform at a low level in most areas of learning, whether verbally or visually based.
- Elena may struggle with learning across many areas and is likely to need support through specific interventions, well- targeted learning materials and a range of different learning methods.

Implications for teaching and learning

- Elena is very likely to need support in all areas of the curriculum and should be known to the learning support specialists within school.
- A test to establish a reading age is recommended to determine whether Elena is able to access the curriculum.
- An intensive phonics course, a course of literacy progress units or additional work to build comprehension and vocabulary may be appropriate.
- Elena is likely to benefit from one-to-one support of a specialist nature.
- More rapid progress will be made if strategies used within school can be further supported at home.

- This is a below average no bias profile, although both verbal and spatial abilities are low.
- The student is likely to perform at a **low level** in most areas of learning, whether verbally or visually based.
- The student may struggle with learning across many areas and is likely to need support through specific interventions, well-targeted learning materials and a range of different learning methods.

What does this look like in the classroom?

Elena's profile is, in some ways, the opposite of Gabriel's: all her scores are consistent, but at the opposite end of the scale. For Elena, attainment is likely to be relatively low, and basic literacy and numeracy skills are very likely to be a target for development.

Students with less developed reasoning abilities often have difficulty in learning abstract concepts.

- Few have effective strategies for learning and remembering. Therefore, they tend to approach learning tasks in a trial-and-error fashion and do not spend much time planning before attempting to solve a problem.
- As a result, they may not transfer knowledge and skills learned in one context to another context, unless prompted to do so.
- Such students may have difficulty detecting relationships, similarities and differences in their new knowledge and they may be easily distracted by obvious but irrelevant details in problems.

To support students like this, teachers need to ensure that **planned objectives, structured activities and likely outcomes are all clearly identified** in language that makes sense to the learner.

- For example, learning objectives can be phrased in the form of a question that is continually referred to during the learning process (*So, can you describe the process of photosynthesis and why it is so important?*).
- Teachers can rephrase and repurpose the question as the lesson progresses to ensure that students remain focused on the key objective.
- The question format also makes it easier for students to respond to both classroom questions and written assignments. As the teacher progresses systematically through the lesson, short specific activities with clearly defined outcomes help to keep students confidently on task.
- Opportunities to share and present their learning in language they understand will further enhance their self-esteem.

Where a written or oral assignment is a key outcome, the teacher should ensure that students have a **clear understanding of the processes, structure and criteria** that will lead to success.

- To ensure this, teachers can model precisely what students need to do, giving examples wherever possible. These can include what students achieved in a previous year. For example, *Have a close look at this work from last year. It's good, but I'm confident that you can do better. Can you see any areas where what we have discussed just now could improve things?*
- The teacher can then break down the criteria that were used to assess student achievement, making clear what each criterion is, what it looks like with a real example and how important it is in relation to the overall mark or grade.
- Throughout this process, the teacher will be modelling expectations for learning and, as Hattie explains, "showing students what success looks like".

Modelling a process derived from an existing example is now often called WAGOLL, or What A Good One Looks Like. There is a growing body of support information around this, including the website Literacy WAGOLL https://www.literacywagoll.com/.

> *Across the grades, when instruction was challenging, relevant, and academically demanding, then all students had higher engagement and teachers talked less – and the greatest beneficiaries were at-risk students.*
>
> Hattie (2012)

Further guidance on how to use modelling successfully in the classroom is provided in the weak quantitative profile for Aelwyn Probert on pages 105-106.

Students with low scores may have difficulty identifying what is important to learn and judging where they should focus their attention in a learning situation.

- Therefore, they need very specific directions before they start a task. For example, if students are required to take notes, all students will benefit if they are given information about what they should take notes on and what these should look like.

Helpful models can support teachers in sharing this understanding. For example, the well-known Cornell method, devised at Cornell University in the 1950s, can be effective in supporting student learning. This method provides a systematic format for condensing and organising notes, using a two-column structure in which a note-taking column (usually on the right) is supported by a questions or keywords column (usually on the left). At the foot of each page a section of five to seven lines is reserved for a summary of the new information in the notes.

In 2008, a Wichita State University study found that using the Cornell method provided high-school students with further support in synthesising and applying new knowledge.

Promoting a **positive attitude to learning is essential** if all students (whether extrinsically or intrinsically motivated) are to give their best in the classroom.

- Establishing routines that promote a positive approach to behaviour management – what Rogers calls 'positive correction' – will directly influence the learning of all students in the classroom.

> *We have to build a relationship – teaching is a relational dynamic journey with your students, it's not simply a little learning factory. Whether we like it or not, the relationship we build will be there whatever – for good, bad or worse.*
>
> Rogers (2017)

Finally, teachers can utilise opportunities for regular breaks that allow students to get up, stretch, move and breathe deeply. These can be fun, but also valuable in re-energising and re-motivating students who

have been sitting in one position for some time. There is a wide range of simple classroom activities that can help to refocus tired minds – one example is https://www.youtube.com/watch?v=m0uiA6UITDw.

Where the teacher has identified students like Elena, specific in-classroom support should include direct support through individual coaching strategies, for example, providing step-by-step resources that refer back to the key lesson objectives, addressing low self-esteem or motivation, or enabling pair-work opportunities with a more able student. More specific activity ideas are included in Table 2.

Examples of strategies for a below average no bias profile

Teachers should be focused on using support strategies that encourage below average no bias profile students to move securely in their learning journey by ensuring that they clearly understand the direction of the learning and the nature of the expected outcomes. This is more than the common (but usually unhelpful) practice of the teacher writing up a learning objective or intention and the students diligently copying this down. As indicated previously, what is essential is providing models of success for the learner that clearly indicate the sequenced steps needed to achieve the learning goal.

1. Designing engaging and effective lessons

As Hattie and Willingham have both made clear, when teachers "look for the interesting beginning to a lesson – for the hook, and the motivating question" – this may not be the attention-grabber that the less-confident learner needs. Willingham expands on this in his book *Why Don't Students Like School?*

When you plan a lesson, you start with the information you want students to know by its end. As a next step, consider what the key question for that lesson might be and how you can frame that question so it will have the right level of difficulty to engage your students and so respect your students' cognitive limitations.

This thinking is linked to the concept of backwards design – whether of a whole curriculum or a single lesson. The key principle is to identify the end in mind. The model has three key stages:

- identify the desired results;
- determine the acceptable evidence;
- plan learning experiences and instruction accordingly.

The concept of backwards design in teacher lesson planning was notably developed by McTighe and Wiggins in their book

Understanding by Design (1998). In subsequent work, they developed the use of the acronym WHERE to identify the process involved in this approach to learning:

- **W** stands for students knowing where they are heading, why they are heading there, what they know, where they might go wrong in the process, and what is required of them.
- **H** stands for hooking the students on the topic of study.
- **E** stands for students exploring and experiencing ideas and being equipped with the necessary understanding to master the standard/outcome being taught.
- **R** stands for providing opportunities for students to rehearse, revise and refine their work.
- **E** stands for student evaluation.

However, teachers should be aware of the dangers of too rigid an adherence to this approach. Teachers' deep understanding of student levels of learning derived from, among other things, evaluations of student learning potential like those identified in *CAT4* assessments, will ensure the flexibility that allows students to be motivated, challenged and rewarded by their learning. Where assessments are driven by a rigid learning goal and where there is little opportunity for student personalisation and teacher serendipity, backwards design can limit the range of student achievement rather than enhance it.

> *We contend that teachers can best raise test scores over the long haul by teaching the key ideas and processes contained in content standards in rich and engaging ways; by collecting evidence of student understanding of that content through robust local assessments rather than one-shot standardised testing; and by using engaging and effective instructional strategies that help students explore core concepts through inquiry and problem-solving.*
>
> McTighe et al. (2004)

Teachers should note the adjectives used here – rich, engaging, effective – and ensure that their own approaches to supporting low even profile learning are not reductive but imaginative, expansive and, of course, supportive.

2. New learning and contextualisation

Teachers should ensure that any new learning is explained in the context of a previous lesson. A lot of the intended benefit of a spiral curriculum, which revisits topics to a deeper and deeper extent, tends to be lost since students do not perceive the curriculum continuity and have not consolidated and remembered the previous content. Teachers should contextualise their lessons within their own subject – for example, *Now, remember last week when we were looking at the ways that the ancient Egyptians preserved their dead? Well, today we shall…'*

In addition, they should make links across subjects, where relevant and applicable – for example, *Last week in English you wrote a persuasive piece of writing on going vegetarian for a week, right? Well, today in history I want you to use some of the same key techniques to write a speech persuading the House of Commons to reduce the voting age to 16*.

Using text types to support cross-curricular subject links can help students to see structural connections in their writing tasks in different subjects. More guidance on this is given in the moderate verbal bias profile of Shauna Matthews (see page 59).

3. Addressing self-esteem and motivation

Teachers should use strategies that help develop student confidence across the ability spectrum, without pandering to low expectations. In this way, they nurture the growth mindset of the whole group by using language that encourages and challenges every student (*OK, now this may look difficult – but I'm confident that you can all do it. Let's give it our best shot!*). Similarly, teachers can use appropriate language to praise both aspiration and method (*Well done! You used some great strategies to work out the answer to that question*).

Whilst there is little empirical evidence that specific growth mindset programmes will advance students' academic achievement, the value of nurturing a 'can do' attitude in the classroom is clear. Teachers may find the material in this presentation a useful starting point - https://www.smore.com/ydvwt-growth-mindset-an-introduction ('to get something you never had, you have to do something you never did').

4. Developing a growth mindset and supporting students with personal knowledge about individual learners

- Knowing students well allows the teacher to harness external interests – for example, sports and hobbies – and use them as a route to develop knowledge, skills and understanding across curriculum subjects.
- Good teachers build relationships with their students firstly by their own good example – promoting a learning culture, showing persistence, acting morally and so on – but then by inculcating that positive attitude in their students by their own actions.
- For developing growth mindset, the following website provides useful support for teachers, https://www.mindsetworks.com alongside Dweck's original text on the subject (2007), as well as this TED Talk video, https://www.youtube.com/watch?v=hiiEeMN7vbQ.

Teachers can help to promote a student's developing sense of self-awareness about their personal learning attributes through positive, caring and clearly defined interactions.

- Average-achieving no bias learners may not share common characteristics in the same way that high-achieving no bias students often do.

Identifying strengths as well as weaknesses in terms of specific interests and achievements can provide achievable relevant goals for students to pursue. The importance of challenge will remain, but it must be contextualised through clearly targeted expectations. Even more than other students, those with less well-developed reasoning abilities will make greater effort and have greater engagement if teachers can discover and build on their interests. Ensuring that teachers use the language of aspiration, challenge and success in the classroom and expect this from their students will generate a learning culture for all.

Users of GL's Pupil Attitudes to Self and School (PASS®) can access resources and interventions for when attitudes, self-esteem and motivation are particularly holding students' learning back from where they would expect.

Where the teacher has identified students like Elena, specific in-classroom support should include direct support through individual coaching strategies – for example, providing step-by-step resources that refer back to the key lesson objectives, addressing low self-esteem or motivation, or enabling pair-work opportunities with a more able student. More specific activity ideas are included in Table 2.

Table 2 Classroom support activities

	Classroom support activities	**Assessing through *CAT4* profiles**
Ages 5-8		
Languages	Use BusyThings apps to individualise the learning: https://www.busythings.co.uk/apps. BusyThings is mapped to the UK national curriculum but is suitable for international applications. The full UK online programme has activities in English and literacy, phonics, maths, science, history, geography, art and music and from Early Years through to Key Stages 1 and 2.	Extend vocabulary learning, from a list of isolated word-wall entries used in specific writing activities to instead feature in a wide range of contexts including spoken usage. Use different vocabulary according to a student's individual developing vocabulary.
Mathematics	Make up bingo cards with numbers that correspond to the correct answers to several predetermined maths problems. Use a 5 x 5 square or whatever number is appropriate according to ability and/or time available. If the correct answer appears on the card, the student can mark it off. The game continues until someone gets five across, down or diagonally and calls out Bingo! Plan the activity as needed with each group taught.	Maths activities at this age – for example, the maths bingo game (left) – allow teachers to easily apply the activity to different *CAT4* bias types. Holding up a completed bingo card, a mini whiteboard or a completed shape or sum are all ways that a teacher can clearly differentiate without checking students' work individually.
Science	Demonstrate the rainbow walking water experiment (https://funlearningforkids.com/rainbow-walking-water-science-experiment-kids/) and then ask students to complete the experiment themselves using a simple science experiment template that includes equipment, method, prediction, results and conclusion sections.	Use a simple science experiment template that includes essential components, for example, prediction, method, result. The teacher must actively demonstrate the process before students attempt their own experiment and write-up. Depending on their *CAT4* bias type, ask students to complete using text or images, work in pairs or present their conclusions.
Humanities and Arts	Watch Ron Berger's Austin's Butterfly video (https://www.youtube.com/watch?v=hqh1MRWZjms) and then recreate this instructional idea using the same idea to learning. Encourage students to objectively analyse their results using appropriate criteria.	Use a wide range of five-minute lesson starters to challenge and support learners so that achievement is spread across a range of skills and attributes.

	Classroom support activities	Assessing through ***CAT4*** profiles
Ages 9-13		
Languages	Using appropriate single word vocabulary, students are encouraged to speak out in pairs in the target language – focusing on accurate pronunciation and awarding themselves points for accuracy (pronunciation can be confirmed electronically using online sources, for example https://www2.rocketlanguages.com/german/pronunciation/).	Use mini whiteboards (https://www.theschoolrun.com/what-are-mini-whiteboards) to improve vocabulary *"Can you write a sentence that includes an adjective, a noun, an adverb and a verb in that order?"*. The teacher can check on answers from students and then offer further challenges if student knowledge is secure (*Right – well done! Now work with the person next to you and put your two sentences together so that they make good sense. Change anything you need to make the new sentence work.).*
Mathematics	Use the 'nrich' programme (https://nrich.maths.org/13922) to present a series of webinar activities that students can work on for between five and ten minutes. During this time, teachers comment online to ask questions on behalf of the class, or share ideas that have arisen. There is an opportunity for classes to upload photos of their work.	With older students, teachers can incorporate further questions when seeking responses, whether for maths or any other subject. One way to distinguish clearly is to use the pose, pause, pounce, bounce technique. It is best described here: https://www.teachertoolkit.co.uk/2011/11/04/pose-pause-bounce-pounce/.
Science	Use the Ames Room experiment from The Royal Institution website (https://www.rigb.org/families/experimental/small-or-far-away) to develop understanding of perception and distance and to demonstrate the practical art/graphic potential in science. Show or download the video on the RI site and use the room templates provided.	Use mini whiteboards again – students can give individual responses easily seen by the teacher, thus allowing for immediate feedback to students who need support. If a student has the correct answer, then the teacher can ask for an explanation or justification (*Can you say more about your answer?*) – this can then be shared with less-secure students.
Humanities and Arts	Promote active rubric/criteria generation with students by delivering a lesson on Keith Haring's art and style before asking students to create their own Haring paintings using a set of specific criteria (for example, the use thick black outlines, primary colours, cross and heart symbols and so on). Encourage students to mark work using the criteria in order to demonstrate objectivity in an art context.	Less able students often believe that they are less creative than more able students. Creativity can be promoted using clear criteria (see above), and teachers can support this in arts-related subjects. Using an age-appropriate selection of classic photographs (for example, some from https://edition.cnn.com/2013/09/01/world/gallery/iconic-images/index.html), teachers can use Bloom's Taxonomy questions to help develop visual literacy (https://www.photopedagogy.com/photo-literacy.html).

	Classroom support activities	Assessing through ***CAT4*** profiles
Ages 14-16		
Languages	Research, create and give a drama-based scenario presentation on a literacy character currently studied.	Explore the language development opportunities in a PGL leadership course - https://create.arduino.cc/projecthub/JulienChateau/spideruino-5915e9?ref=tag&ref_id=lego&offset=0.
Mathematics	Ask students *Why?* and *What if...?* to generate deeper thinking before giving extension activities like solving magic square problems.	Undertake an Extended Project Qualification (EPQ). Students follow an individual research project on a topic of their choice and receive an internationally recognised qualification on completion. Projects can be multidisciplinary and can allow students to further their interest in STEM and gain experience of extended practical work. Explore the range of real-world STEM projects from UK-based Crest Awards - https://www.crestawards.org/.
Science	Explore the Arduino Hub and identify Lego projects that students could undertake independently (for example, making a robotic arachnid: https://create.arduino.cc/projecthub/JulienChateau/spideruino-5915e9?ref=tag&ref_id=lego&offset=0).	
Humanities and Arts	Explore the Doodle for Google site and encourage students to research and then develop a Google doodle to be entered in competition - https://doodles.google.com/d4g/.	Use Model United Nations (MUN) to provide students with a forum to hone skills in diplomacy, negotiation, critical thinking, compromise, public speaking, writing and research - https://www.nmun.org/.

Profiles with relative strengths and weaknesses

In the three *CAT4* profiles considered so far, all three show consistent scores across the batteries of tests. But for about 33% of students there is a distinct strength or weakness in either verbal reasoning or spatial ability.

Example of a mild verbal bias profile

CAT4 Individual student report for teachers

CAT4

Name: Alex Honkanen			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	Level: D	Age: 11:04	Sex: Female

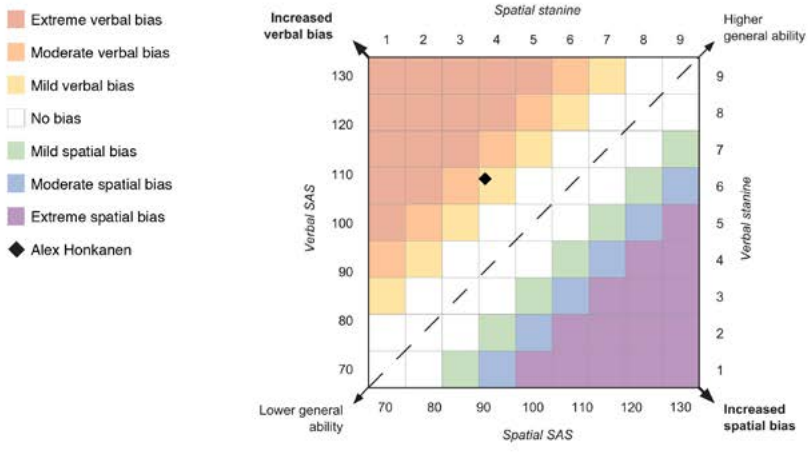
Scores

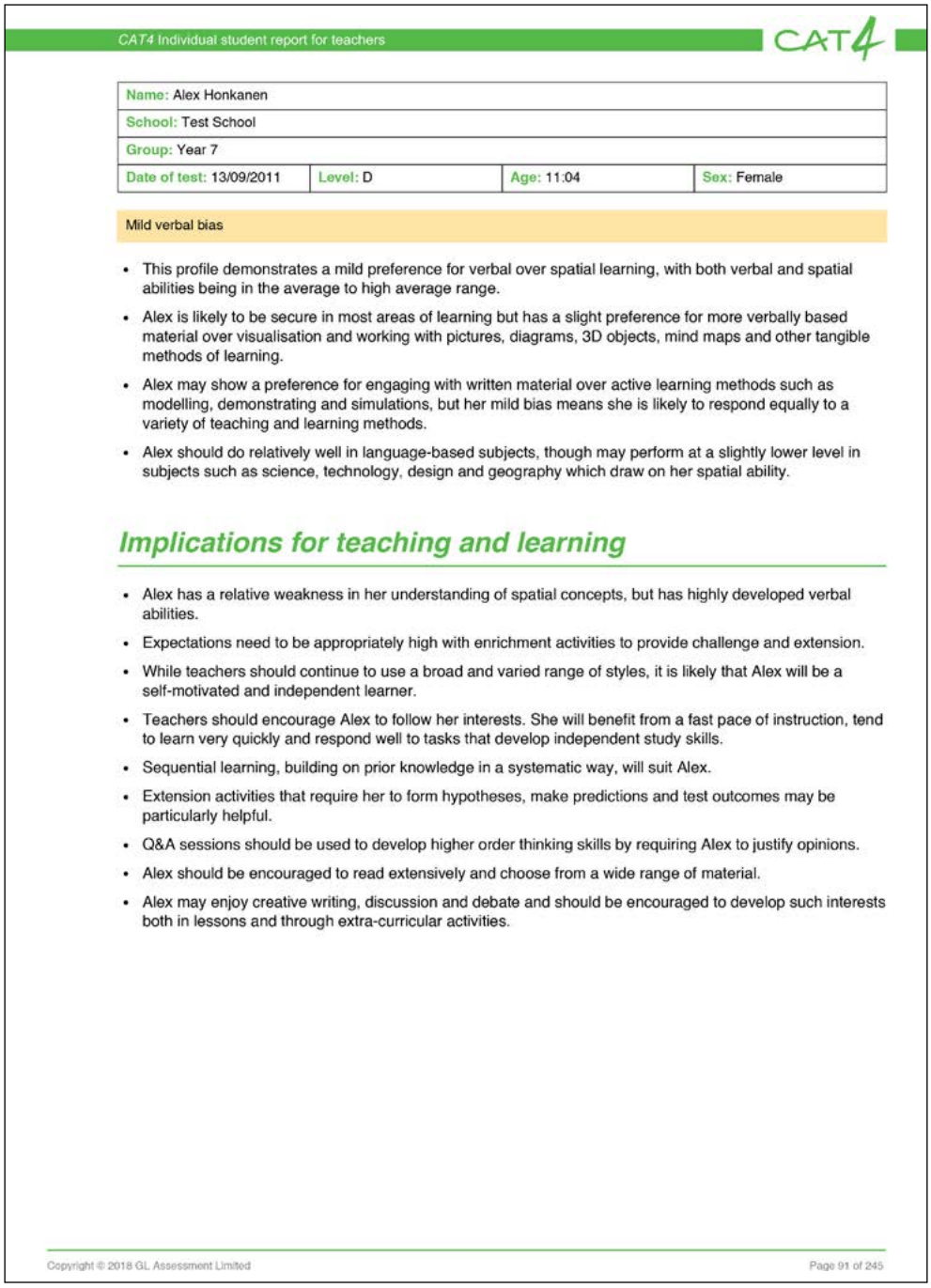
Battery	No. of questions attempted	SAS	NPR	ST	GR (/60)	SAS (with 90% confidence bands) 60 70 80 90 100 110 120 130 140
Verbal	46/48	**109**	72	6	14	
Quantitative	27/36	**103**	58	5	=18	
Non-verbal	31/48	**99**	48	5	=31	
Spatial	15/36	**90**	26	4	=47	
Mean	-	**100**	-	-	-	

Profile summary

The analysis of *CAT4* scores allows all students to be assigned a profile; that is they are assigned to one of seven broad descriptions of their preferences for learning. The Verbal Reasoning and Spatial Ability Batteries form the basis of this analysis and the profiles are expressed as a mild, moderate or extreme bias for verbal or spatial learning or, where no bias is discernable (that is, when scores on both batteries are similar), as an even profile.

The black diamond shows Alex's profile, which is indicated by the coloured band.





CAT4 Individual student report for teachers

CAT4

Name: Alex Honkanen			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	**Level:** D	**Age:** 11:04	**Sex:** Female

Mild verbal bias

- This profile demonstrates a mild preference for verbal over spatial learning, with both verbal and spatial abilities being in the average to high average range.
- Alex is likely to be secure in most areas of learning but has a slight preference for more verbally based material over visualisation and working with pictures, diagrams, 3D objects, mind maps and other tangible methods of learning.
- Alex may show a preference for engaging with written material over active learning methods such as modelling, demonstrating and simulations, but her mild bias means she is likely to respond equally to a variety of teaching and learning methods.
- Alex should do relatively well in language-based subjects, though may perform at a slightly lower level in subjects such as science, technology, design and geography which draw on her spatial ability.

Implications for teaching and learning

- Alex has a relative weakness in her understanding of spatial concepts, but has highly developed verbal abilities.
- Expectations need to be appropriately high with enrichment activities to provide challenge and extension.
- While teachers should continue to use a broad and varied range of styles, it is likely that Alex will be a self-motivated and independent learner.
- Teachers should encourage Alex to follow her interests. She will benefit from a fast pace of instruction, tend to learn very quickly and respond well to tasks that develop independent study skills.
- Sequential learning, building on prior knowledge in a systematic way, will suit Alex.
- Extension activities that require her to form hypotheses, make predictions and test outcomes may be particularly helpful.
- Q&A sessions should be used to develop higher order thinking skills by requiring Alex to justify opinions.
- Alex should be encouraged to read extensively and choose from a wide range of material.
- Alex may enjoy creative writing, discussion and debate and should be encouraged to develop such interests both in lessons and through extra-curricular activities.

- Some students with this profile will have low average or below average scores for verbal reasoning, and relatively weaker spatial ability, but the gap between scores will be narrow.
- Students with this profile will have a slight bias for learning through reading, writing and discussion.

What does this look like in the classroom?

Alex's profile shows a preference for verbal over spatial learning. She is likely to be self motivated and should respond well to more challenging extension activities.

- Students with a relative strength in verbal reasoning will generally do best when they talk and write about their learning – they can be adept language users.
- They are likely to participate in group discussions, work well with a partner, show high standards of written expression in a range of subjects, enjoy word games and similar activities, have an extensive vocabulary and demonstrate creative writing skills.
- They will tend to do relatively well in language-based subjects where verbal skills are at the fore (for example, English, history, modern languages and other humanities subjects).
- Where verbal scores are high, these students will be quick to see links between verbal concepts and are often adept at interpreting and understanding the nuances and ambiguities of language (for example, distinguishing between everyday uses of words and their subject-specific uses, such as with energy, resistance and so on).

Students like Alex, with a relative strength in verbal reasoning, will tend to be **good at developing ideas and lines of thinking in continuous text** and explaining a process logically.

- One of the best ways to build reasoning skills is to participate in real reasoning dialogues.

Students with high verbal reasoning scores can further **develop their skills through group work** by being used actively to promote the value of group work. They can also play a prominent role in encouraging other students who may be less confident in sharing their thinking in a group.

- This is where the *CAT4* profiles can be particularly useful in ensuring that student combinations are supporting both intellectual and social skills development.

Since their spatial scores are relatively low, high-verbal-reasoning scoring students may need some support in using the kind of visual models that teachers might think will automatically support learning.

- Such students may need support in subjects such as science, geography or technology where diagrams, graphs, charts, infographics and other largely non-verbal forms are common.

Mild verbal bias students tend to have **higher national test and examination attainment than students with a similar mean *CAT4*** score who have their strength in the quantitative, spatial or non-verbal Batteries.

- Overall, therefore, higher verbal strength can compensate for lower scores in the quantitative, spatial and non-verbal areas. However, if the level of the scores is low (stanines 1 to 3), then students are still likely to experience problems, particularly in mathematics.

- For such students, their verbal strength can be used to present mathematics problems in a different way.

More girls than boys tend to have strong verbal bias, whereas mild verbal bias (see page 50) tends to be more common in boys.

- This reflects the fact that girls, on average, score around two SAS points higher than boys on the Verbal Battery (there is no significant sex difference in mean score on the Quantitative, Spatial or Non-verbal Batteries).

- Teachers should not be surprised, therefore, if they identify different proportions of boys and girls with these profiles within their classes.

Examples of strategies for a mild verbal bias profile

The following specific strategies can be effective at building on the strengths and addressing the weaknesses of mild verbal bias profile students.

1. Planning effective group work

The role of group work in the classroom is a much-discussed aspect of classroom pedagogy. Indeed, it can often be part of the ongoing traditional versus progressive debate. However, this debate ignores the core questions that need to be asked before any group work begins:

- Why are students getting into groups?
- What is the desired outcome?
- Most importantly, will group work achieve better results than students working individually?

Specifically – and in relation to the *CAT4* profiles – teachers should consider a further key question: Will this group with these student profiles work better than this group with a range of different profiles?

The variables that need to be considered when students are working together are significant. The *CAT4* tests are all about 'unlocking potential', and so considering the factors of both student ability and student potential is a good starting point. However, before this (and linking to the concept of 'backwards design' as discussed earlier on page 43) comes the key question indicated above: What do I want the students to know, be able to do and to understand at the end of their group work process?

Following on from this, teachers should consider the specific roles given to students in the group. This is important because group work offers an opportunity for high-quality interactions between the members of the group and, therefore, clearly defined roles are crucial. There is always a danger in group work of what education researcher, Kagan (2019), rather disparagingly calls the 'hogs and logs' syndrome – where some students dominate the proceedings at the expense of those who merely observe or lose interest. Assigning specific roles ensures that students will be both engaged throughout the process and accountable to other members in the group. This process also enables teachers to usefully disrupt what might be stereotypical roles and get beyond

any gendered assumptions that students may have about either themselves or their potential partners in a group situation.

Specific roles in groups have been codified into what is sometimes called the Process Oriented Guided Inquiry Learning (POGIL) model. This requires students to work in a group (or more accurately, a team) that has clearly defined roles on a series of process-guided activities. The four roles are identified as follows:

- **Manager** or **Facilitator**: manages the group by helping to ensure that the group stays on task, is focused, and that there is room for everyone in the conversation.
- **Recorder**: keeps a record of those who were in the group, and the roles that they play in the group. The recorder also records critical points from the small group's discussion along with findings or answers.
- **Spokesperson** or **Presenter**: presents the group's ideas to the rest of the class. The spokesperson should rely on the recorder's notes to guide their report.
- **Reflector** or **Strategy Analyst**: observes team dynamics and guides the consensus-building process (helps group members come to a common conclusion).

Teachers will find this guide a useful introduction to the process: https://pogil.org/uploads/attachments/cjay281cc08qzw0x4ha9nt7wd-implementationguide.pdf.

Teachers may find that they wish to adapt and develop these specific group roles or explore other roles, especially as students become more adept at understanding the value of an assigned role. For example, these might include giving a student a questioning role in which they listen carefully for different points of view and note them for future consideration (*That's an interesting view – can I ask whether others in the group agree?*) or where they challenge viewpoints with questions (*Can I just check on why you said that?*)

It is important that teachers make clear to students why they are assigning any specific roles. This starts with describing the purpose of the role, the tasks that might be involved, examples of the kinds of questions that could be asked, and ensuring an understanding that roles will be shared amongst the students. In general, teachers should be aware that groups of three often create a 'passenger' whose role becomes increasingly marginal,

and so working in groups of four with each student having an assigned role is likely to be more productive. Teachers may also wish to consider students working in pairs to develop their working knowledge of the lesson content – for example, analysing different points of view, outlining the key premises of a problem, reading and checking understanding of key facts and opinions – before sharing and developing the new learning in a group of four.

With the group structure clear and groups constituted to maximise both learning and collaborative skills, teachers can monitor that the roles are working properly. For example, where a student is not following their role or appears to be taking over another role, the teacher can step in and remind the student that they must get back on task. It is also this clarity that reciprocally helps students to 'buy in' to their assigned roles.

Effectively planned and managed group work can enhance the learning in any subject, not just those like drama, music or PE where collaboration is a common feature of lessons. Balancing the learning and intellectual skills developed is an important consideration of any group work – activities, including those identified in the Harvard Visible Thinking project such as Compass Points, See-Think-Wonder, Think-Pair-Share and 3-2-1 Bridge, can be used in small group contexts to not only develop deeper thinking skills but also help to build students' confidence in expressing opinions, working collaboratively and evaluating viewpoints.

These specific activities (or 'thinking routines') are deliberately simple tools for 'scaffolding' thinking that can be woven into any teacher's repertoire of classroom strategies. An introductory video from the project can be viewed at: https://www.youtube.com/watch?v=oKV_S5NpDdc.

The teacher will be monitoring the outcomes of group activities and looking to see how effective they are in taking a student like Alex forward in her learning. If successful, then further, more extended collaborations can be developed. Not only can ideas be shared and tasks delivered together, but collaboration can extend to evaluating a partner's ideas or monitoring their work. This kind of approach is rooted in Vygotsky's key principles of the ZPD and the critical role of the MKO. ZPD is the understanding that learning is best when taken step-by-step, or 'scaffolded', and the MKO is the person (parent, teacher or helpful peer) who can help the learner to progress. See earlier discussion on page 35.

Ron Ritchhart's book *Making Thinking Visible* describes the theory behind these approaches but also raises some key questions about higher-order thinking skills and Bloom's Taxonomy, which many teachers will be familiar with (see page 73).

2. Encourage students to talk about their learning

Teachers can encourage mild verbal bias students to talk through their learning – for example, writing a history timeline for the key events leading up to the start of World War I – and then present this to their peers. Their well-developed language skills can be used to support teachers as they explain key concepts. After all, we often recognise that sometimes using more informal 'student talk' can be more helpful to ensure whole-class understanding than the formalities and technical language of 'teacher talk'.

Talking about thought processes will be discussed again under the sections on modelling and on metacognitive skills later on.

3. Pair students with different strengths

Pairing a mild verbal bias student with a student who has scored highly in the Quantitative Reasoning Battery is likely to benefit the learning of both, and using a well-established talk routine like Think-Pair-Share can help to make this happen in the classroom. As always, simple strategies like this need to be clearly explained in order for them to be most effective. The process is clearly explained in a post from Gonzales' blog, Cult of Pedagogy, which can be read at: https://www.cultofpedagogy.com/think-pair-share/.

Students with strong quantitative reasoning can demonstrate and share their approach to numbers for the benefit of verbal biased students. For example, students could work in pairs using a tsunami warning game (http://www.stopdisastersgame.org/stop_disasters/) to explore how quantitative data can be used in a real-life scenario and form the basis of effective group discussion about the decisions taken to minimise tsunami damage. Teachers wishing to find out more about innovative group-work approaches should explore the suggestions and references in Alex Honkanen's profile (see page 50).

Listening to young learners talking freely about mathematics problems can be inspiring – as students verbalise their maths thinking, the teacher can start to prepare for the share section of the activity, encouraging the students to talk about how they and their partner solved the problem. This is the opportunity for the teacher to integrate some of those more challenging questions into the mix: *What did you think about doing first? Did you change your mind – and what made you agree to do that? What do others think about this?* Most significantly, teachers are able to make formative judgements easily as they listen to the class and then have their thinking confirmed (or not) in the share part of the activity. Students with a mild verbal bias learn by using their vocabulary strengths when working with a partner – for example, reading a passage of writing for meaning before presenting a tableau of a key idea in the text. This works equally as well for a scientific process such as the water cycle as for a key scene from *Tess of the D'Urbervilles*. It is applicable to any age and any subject. The teacher will determine the ground rules, but essentially students work in groups and assume a still position that forms part of the whole picture of the task. Props may be used if the teacher wishes. Here's an example of a tableau in action from *The Teacher's Toolkit* (note the teacher's comment that the students are "so used to relying on oral speech to explain things, and not being able to do that really shows: can they get the concept?"): https://www.youtube.com/watch?v=aHooiRHMkr0.

Example of a moderate verbal bias profile

CAT4 Individual student report for teachers

CAT4

Name: Shauna Mathews			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	Level: D	Age: 11:04	Sex: Female

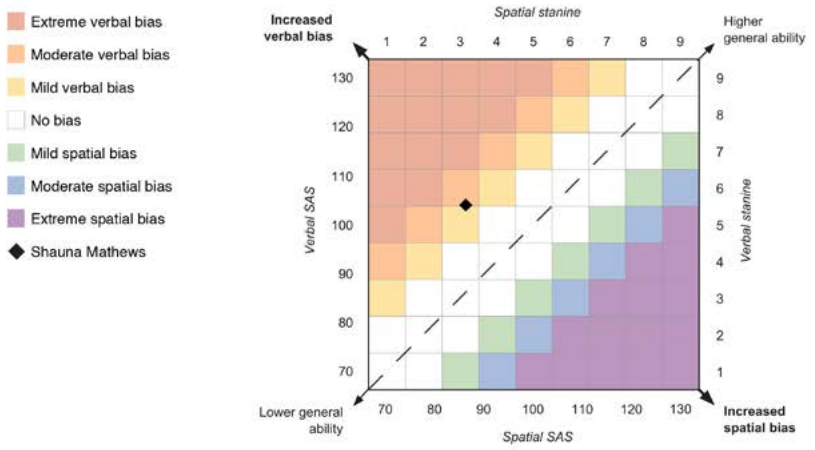
Scores

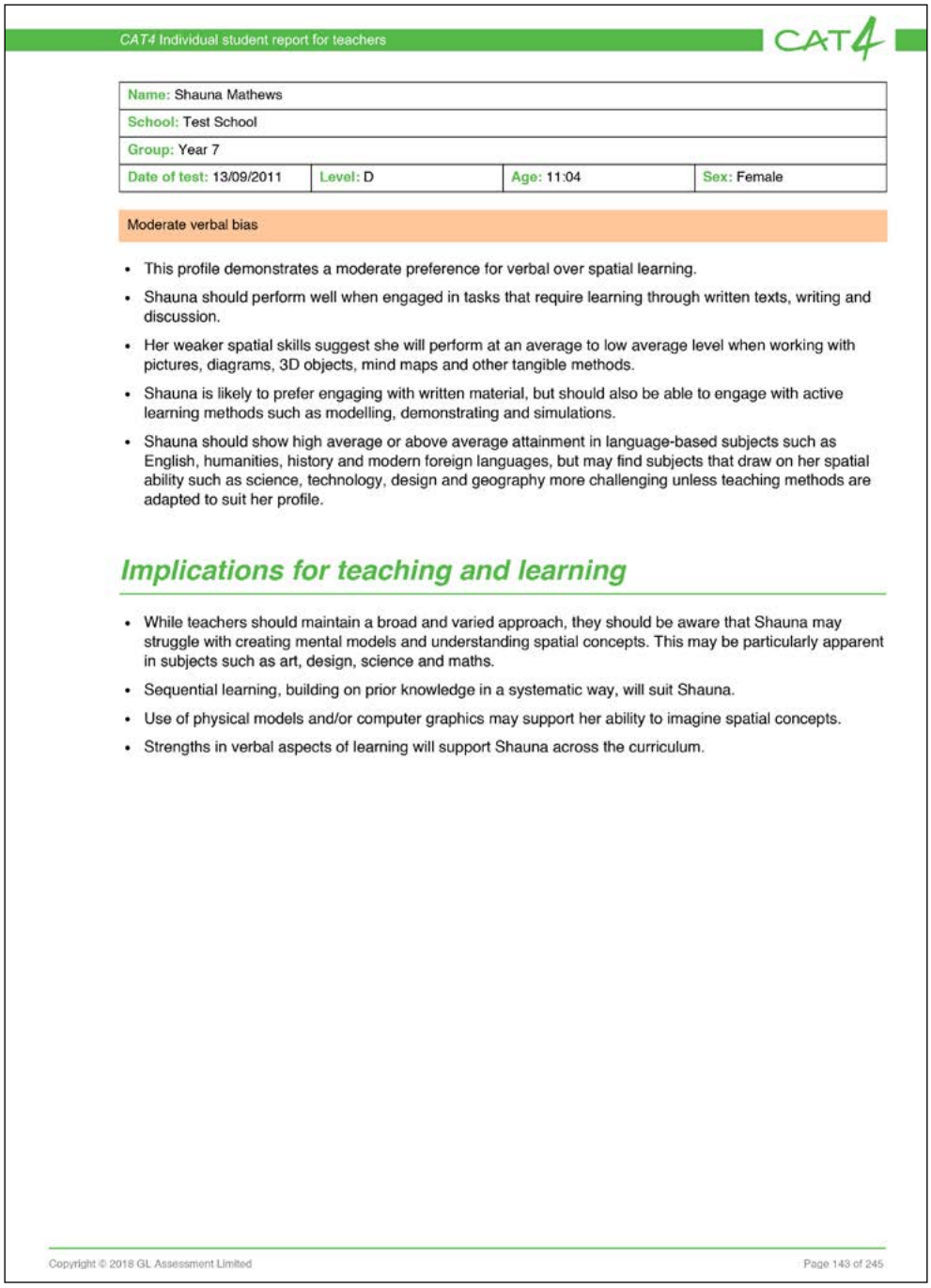
Battery	No. of questions attempted	SAS	NPR	ST	GR (/60)	SAS (with 90% confidence bands) 60 70 80 90 100 110 120 130 140
Verbal	48/48	**104**	60	6	=22	
Quantitative	36/36	**84**	14	3	=54	
Non-verbal	48/48	**91**	28	4	=41	
Spatial	36/36	**86**	18	3	51	
Mean	-	**91**	-	-	-	

Profile summary

The analysis of *CAT4* scores allows all students to be assigned a profile; that is they are assigned to one of seven broad descriptions of their preferences for learning. The Verbal Reasoning and Spatial Ability Batteries form the basis of this analysis and the profiles are expressed as a mild, moderate or extreme bias for verbal or spatial learning or, where no bias is discernable (that is, when scores on both batteries are similar), as an even profile.

The black diamond shows Shauna's profile, which is indicated by the coloured band.





CAT4 Individual student report for teachers

CAT4

Name: Shauna Mathews			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	**Level:** D	**Age:** 11:04	**Sex:** Female

Moderate verbal bias

- This profile demonstrates a moderate preference for verbal over spatial learning.
- Shauna should perform well when engaged in tasks that require learning through written texts, writing and discussion.
- Her weaker spatial skills suggest she will perform at an average to low average level when working with pictures, diagrams, 3D objects, mind maps and other tangible methods.
- Shauna is likely to prefer engaging with written material, but should also be able to engage with active learning methods such as modelling, demonstrating and simulations.
- Shauna should show high average or above average attainment in language-based subjects such as English, humanities, history and modern foreign languages, but may find subjects that draw on her spatial ability such as science, technology, design and geography more challenging unless teaching methods are adapted to suit her profile.

Implications for teaching and learning

- While teachers should maintain a broad and varied approach, they should be aware that Shauna may struggle with creating mental models and understanding spatial concepts. This may be particularly apparent in subjects such as art, design, science and maths.
- Sequential learning, building on prior knowledge in a systematic way, will suit Shauna.
- Use of physical models and/or computer graphics may support her ability to imagine spatial concepts.
- Strengths in verbal aspects of learning will support Shauna across the curriculum.

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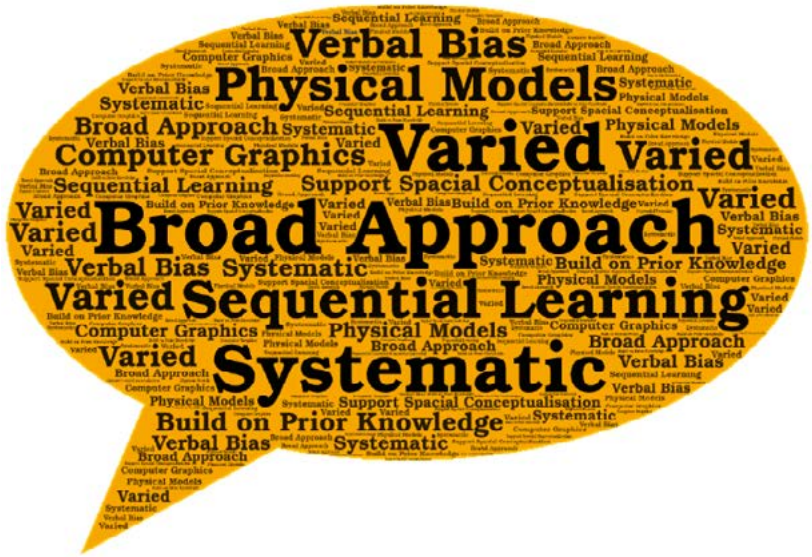
- Students with this profile are more likely to prefer engaging with written material and should show high average or above average attainment in language-based subjects such as English and history.
- These students may find subjects that draw on their spatial ability, such as science, technology, graphic design and geography, more challenging.
- The opportunity to link language-based skills with a structured understanding of writing, including text-type guidance, is likely to support these students' work in more STEM-based subjects.
- Teacher modelling, classroom demonstrations and guided instruction are likely to support Shauna's achievement across the curriculum.

Shauna's profile demonstrates a moderate preference for verbal over spatial learning. Shauna should perform well when engaged in tasks that require learning through written texts, in writing activities and in discussion. Her weaker spatial skills suggest that she will perform at an average to below average level when working with pictures, diagrams, 3D objects, mind maps and other tangible methods.



What does this look like in the classroom?

Shauna's profile indicates that she will be **hindered by her weaker spatial skills** and so will need support when working with pictures, diagrams, mind maps and so on. These students' areas of weakness can be developed through active **teacher modelling** (see page 62).

- Step-by-step modelling is likely to be particularly important in mathematics and similar subjects where processes can be broken.

Students like Shauna are likely to be **confident with written texts** and can also explore the process described in teacher modelling themselves.

- This can either be done actively through their own writing or more passively through exemplar material being provided as the basis for discussion and/or redrafting.
- The student could be guided by a teacher's choice of texts or using their own material. In this respect, teachers should explore the valuable use of both published material in draft form and the work of students from the previous year group – this can be excellent for reassuring learners about the processes of writing and how real redrafting works.

Additionally, with a verbal score of 104 (significantly higher than her other scores), Shauna is going to benefit in the classroom from a focus on asking questions.

- Questioning is a key means of knowledge transfer.
- It accounts for up to one-third of all teaching time, second only to the time devoted to explanation and, as Claxton (2003) is quoted to have said, "Good learning starts with questions, not answers".

Examples of strategies for moderate verbal bias profile

This section will revisit the technique of modelling, since it is such an important skill for teachers to develop.

1. Effective teacher modelling

Modelling is one of the most effective ways of helping all students become more confident and skilled because it allows students to learn from the teacher demonstrating expertise in a process. The reason this is so important is that many students may have the necessary subject knowledge but lack both the experience of using process skills and the confidence to experiment and take risks when they are learning. For example, in writing, once students have the knowledge and understanding of the writing requirements – text type, purpose and audience, content and structure – the writing skills can be modelled, which enhances confidence and develops key skills through a shared activity, where it feels safe to take risks and make mistakes. Modelling shows how the subject works in the real world.

The focus on structure rather than content allows teachers to use the approach in a number of cross-curricular contexts. In a study of mathematics instruction, for instance, the most effective maths teachers spent about 23 minutes of a 40-minute period in lecture, demonstration, questioning, and working examples. In contrast, the least effective teachers spent only 11 minutes presenting new material. The more effective teachers used this extra time to provide additional explanations, give many examples, check for student understanding, and provide sufficient instruction so that the students could learn to work independently without difficulty.

But what do we mean by modelling, and in what ways is it different from demonstrating?

Modelling starts with an explanation and a demonstration of the end-to-end process, which:

- are presented in a clear series of sequenced steps
- include some thinking aloud about key decisions
- invite further questions about the process
- show the finished product from the process.

After such a presentation, the learners are given an opportunity to work some examples of the process, feed questions back, and work towards becoming independent users of the skill. All students will benefit from seeing writing processes and procedures modelled and then having an opportunity to continue this staged writing process with scaffolded support before producing their own independent text.

The most useful analogy might be with the popular genre of television cookery programmes. These are popular because they encourage viewers to try something new and different. The process is more than a passive demonstration, as the viewer is watching a description, an explanation and a demonstration of the process – and this is often conducted in 'real time'. The celebrity chef makes their expertise seem accessible to the ordinary viewer.

The advantage of a live real-time presentation is that the teacher is able to slow down the process if required and ensure that student support and challenge is balanced to meet specific needs. Finally, the teacher is able to demonstrate clearly what the finished product should be like, ensuring that students have a far greater chance of success. As noted earlier (see Bisset Billy on page 31), this is simply what Hattie calls "showing students what success looks like".

The modelling process is characterised by deliberate and structured teacher instruction using a 'small-step' approach – an idea very close to Vygotsky's original ZPD concept (see page 35). Teaching in small steps and making sure that students have understood and can apply the learning takes time, but it does ensure that all learners are able to follow the steps, rather than leaving some students behind and causing frustration.

An approach that prioritises the learning of new materials, followed by some guided student practice before students are allowed to work independently, has been shown to be the most effective approach to successfully learning new knowledge – see Rosenshine (2012) as cited earlier on pages 36-37. The movement is one from dependence to independence; from teacher modelling through guided support to individual independent demonstration of new learning. Additionally, as Figure 4 indicates, teachers can confidently conclude this process with an evaluation that explicitly uses the criteria and involves the students if desired.

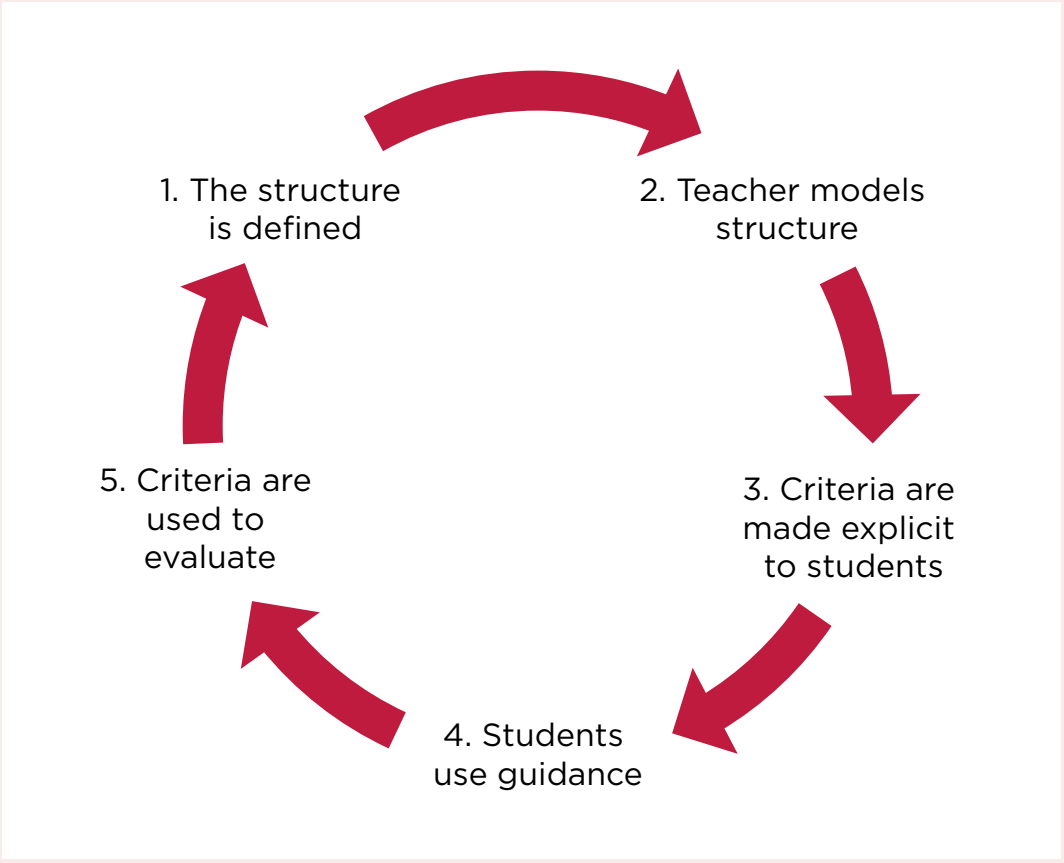


Figure 4 A simple modelling process.

Note that this kind of learner self-evaluation only works effectively when the criteria have been clearly demonstrated and exemplified by the teacher.

2. Modelling to support verbal skills

Modelling text types (whether non-fiction or fiction genres) can be done most easily in the classroom by teachers thinking about three different levels of language knowledge: word level, sentence level and whole-text level. The generic non-subject specific ideas provided below will support this development in the classroom:

- **Word level**. Teachers can try paired vocabulary work, for example, a cloze exercise, matching words as synonyms or redrafting in pairs with a specific focus on an aspect of vocabulary. This could lead to a whole-class focus on the whiteboard while the teacher redrafts using a section of text containing the words students have already focused on in pairs.
- **Sentence level**. Teachers can use card-sort exercises, for example, matching technique to example, then writing a sentence to demonstrate a technique, such as rhetorical questions. Teachers could use a word-bingo activity where a list of persuasive techniques can be matched to examples of writing before students write appropriate sentences on a given topic. These sentences can then be incorporated into a whole-class modelling activity.
- **Whole-text level**. Teachers plan that students work in pairs to draft a short paragraph before passing it on to another pair of students to complete a following paragraph. Students could plan a narrative text together with the teacher and then write the narrative using different starting points and flashback techniques. Different versions could be compared to the modelled structure.

It should be emphasised again that this approach requires the teacher to actively model the learning, perhaps thinking aloud in front of the class while demonstrating the new learning. Rosenshine makes clear in his summary of the research into these direct teaching approaches that “compared with the successful teachers, the less effective teachers gave much shorter presentations and explanations, and then passed out worksheets and told students to solve the problems”.

3. Asking questions

Questions help students to reflect on information, encourage discussion and generate new ideas but they are even more useful for the teacher. Questions enable a teacher to determine how well any new learning has been understood. More successful teachers ask more questions and make sure they are process questions – simply, the *What*, *Why*, *How*, *When* and *Where* questions – and, in a more complex construct, these more probing alternatives:

- *Can you describe how…?*
- *What happened after…?*
- *What differences are there between…?*
- *Can you give another example of…?*
- *What do you think was the motive behind…?*
- *How many ways can you…?*
- *What impressed you about…?*
- *How would you have handled…?*

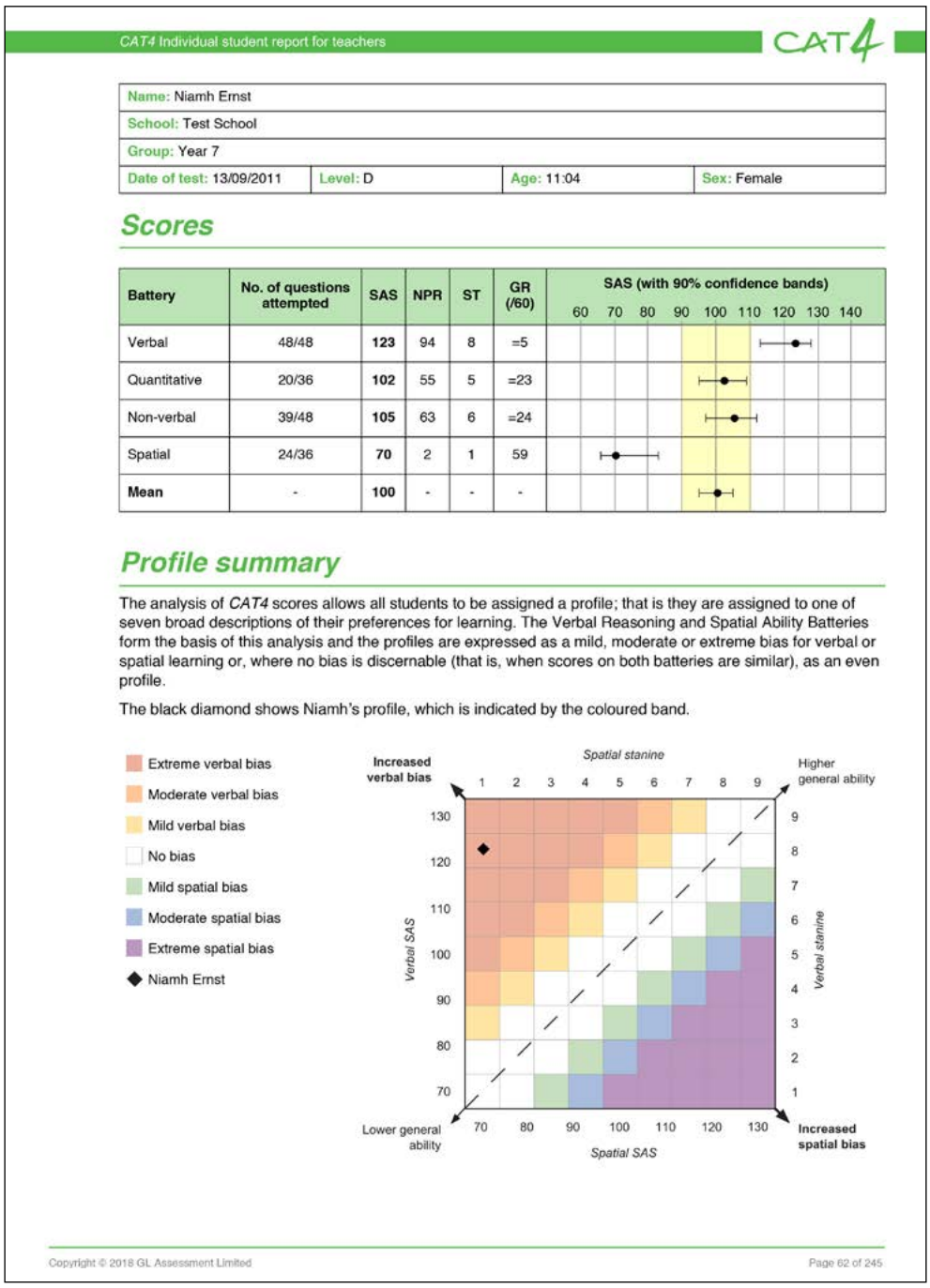
Teachers can support the development of such verbal skills by increasing the amount of imaginative ways they can involve all students in a group in answering questions. For example, giving the answer to a teacher question to a partner, summarising an answer on a mini whiteboard and showing the teacher, and moving from a pair discussion about learning which focuses on a series of What? questions to a group of four that tackles more demanding Why? questions.

Questions can be effectively grouped into:

- Exemplifying and Specialising questions: for example, *Give me one or more examples of…; Describe, demonstrate, tell, show, choose, draw; Find an example of…*
- Completing, Deleting and Correcting questions: for example, *What must be added/removed/altered to ensure/allow/contradict?; Tell me what's wrong with…?; What needs to be changed so that…?*
- Changing, Varying, Reversing and Altering questions: for example, *What if…?; If this is the answer to a similar question, what was the question?; Can you do this another way?*

It is important that teachers develop a repertoire of all these kinds of questions. As well as allowing teachers to determine how much a class understands and helping to draw students into the lesson, keeping them interested and alert, they have an additional symbolic value. They send a clear message that students are expected to be active participants in the learning process.

Example of an extreme verbal bias profile



CAT4 Individual student report for teachers

CAT4

Name: Niamh Ernst			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	**Level:** D	**Age:** 11:04	**Sex:** Female

Scores

Battery	No. of questions attempted	SAS	NPR	ST	GR (/60)	SAS (with 90% confidence bands) 60 70 80 90 100 110 120 130 140
Verbal	48/48	**123**	94	8	=5	
Quantitative	20/36	**102**	55	5	=23	
Non-verbal	39/48	**105**	63	6	=24	
Spatial	24/36	**70**	2	1	59	
Mean	-	**100**	-	-	-	

Profile summary

The analysis of *CAT4* scores allows all students to be assigned a profile; that is they are assigned to one of seven broad descriptions of their preferences for learning. The Verbal Reasoning and Spatial Ability Batteries form the basis of this analysis and the profiles are expressed as a mild, moderate or extreme bias for verbal or spatial learning or, where no bias is discernable (that is, when scores on both batteries are similar), as an even profile.

The black diamond shows Niamh's profile, which is indicated by the coloured band.

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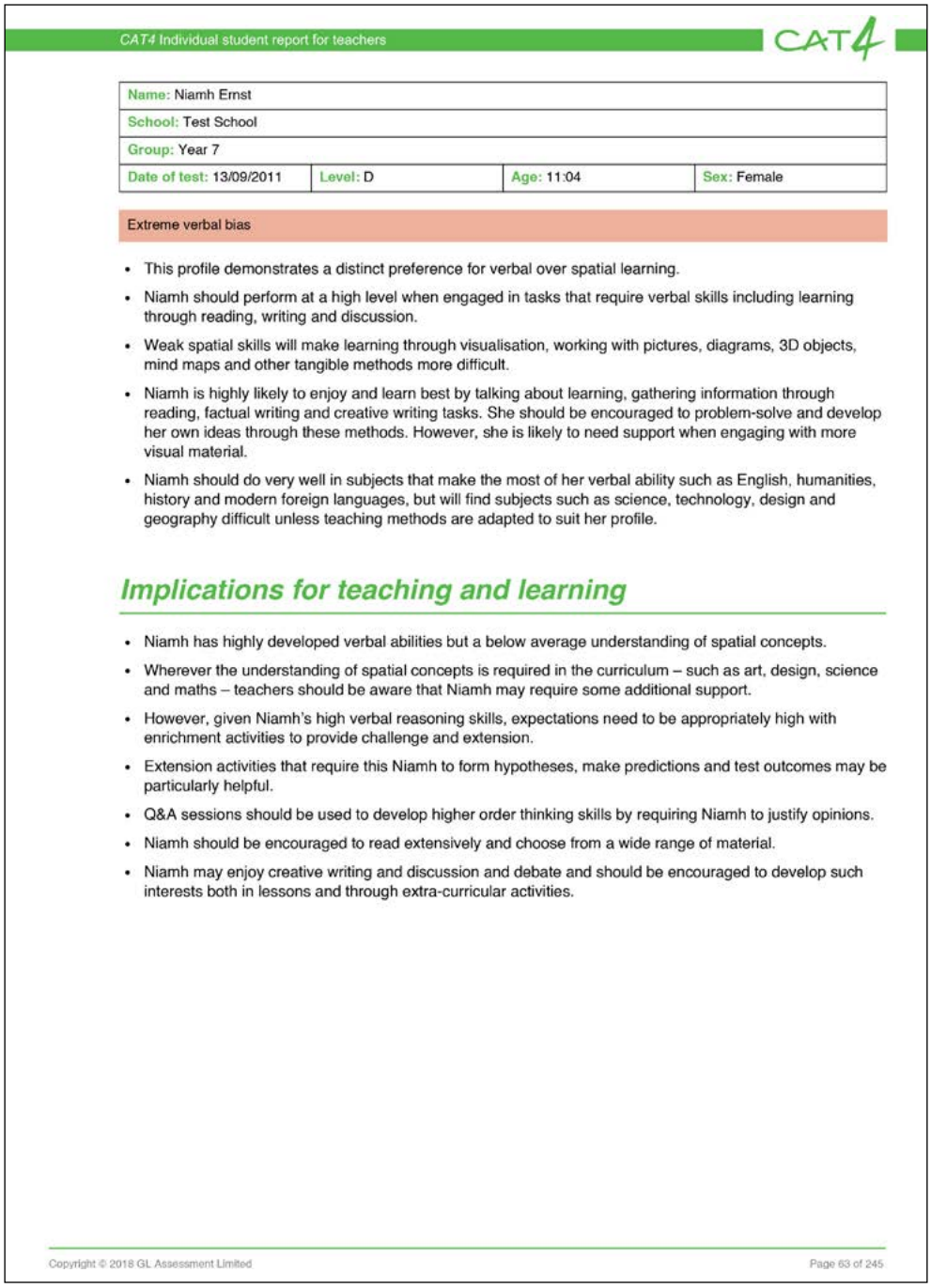


CAT4 Individual student report for teachers

CAT4

Name: Niamh Ernst			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	**Level:** D	**Age:** 11:04	**Sex:** Female

Extreme verbal bias

- This profile demonstrates a distinct preference for verbal over spatial learning.
- Niamh should perform at a high level when engaged in tasks that require verbal skills including learning through reading, writing and discussion.
- Weak spatial skills will make learning through visualisation, working with pictures, diagrams, 3D objects, mind maps and other tangible methods more difficult.
- Niamh is highly likely to enjoy and learn best by talking about learning, gathering information through reading, factual writing and creative writing tasks. She should be encouraged to problem-solve and develop her own ideas through these methods. However, she is likely to need support when engaging with more visual material.
- Niamh should do very well in subjects that make the most of her verbal ability such as English, humanities, history and modern foreign languages, but will find subjects such as science, technology, design and geography difficult unless teaching methods are adapted to suit her profile.

Implications for teaching and learning

- Niamh has highly developed verbal abilities but a below average understanding of spatial concepts.
- Wherever the understanding of spatial concepts is required in the curriculum – such as art, design, science and maths – teachers should be aware that Niamh may require some additional support.
- However, given Niamh's high verbal reasoning skills, expectations need to be appropriately high with enrichment activities to provide challenge and extension.
- Extension activities that require this Niamh to form hypotheses, make predictions and test outcomes may be particularly helpful.
- Q&A sessions should be used to develop higher order thinking skills by requiring Niamh to justify opinions.
- Niamh should be encouraged to read extensively and choose from a wide range of material.
- Niamh may enjoy creative writing and discussion and debate and should be encouraged to develop such interests both in lessons and through extra-curricular activities.

What does this look like in the classroom?

Students like Niamh Ernst who have an extreme verbal bias/strength in verbal reasoning will tend to be **good at developing ideas and lines of thinking in continuous text** and explaining a process logically.

One of the best ways to build and share these verbal reasoning skills is to participate in real reasoning dialogues. One of the ways in which this can be done is through what are called Fermi questions, after the Nobel Prize-winning physicist Enrico Fermi who challenged his students to use common sense, estimation and numerical reasoning to work out the answer to quantitative problems that were difficult or impossible to accurately measure.

He asked them questions that had a limited amount of information so that students had to think of additional questions to get closer to the answer. The focus was on the process of questioning rather than achieving a wholly accurate answer, with the aim of developing both creative thinking and problem-solving skills.

Fermi questions can range across many subjects and disciplines, but these examples should both inform and inspire!

- How many ping pong balls would it take to fill your classroom?
- How many people would fit shoulder to shoulder in the corridor outside your classroom?
- If all the people in the world moved to Wales, how crowded would it be?
- How many litres of water does the school use each week?
- How many hairs are on your head?
- How long would it take to count to one million?

- How many Mars bars would it take, lined up end to end, to reach from London to Birmingham?
- How many grains of rice in a 25kg bag?

Fermi showed that by making sensible assumptions, reasonable estimates and using some simple calculations, remarkably accurate answers can be reached. The value of this kind of investigative approach is obvious – but there is an additional benefit for a student like Niamh. With her very low spatial reasoning score (70), Niamh needs to use her verbal and quantitative skills to develop her spatial abilities. The opportunity to work in a small group with a balance of *CAT4* profile student strengths and with a range of specific group roles (see page 67) will build her spatial confidence and progressively enhance her spatial skills. It should also be noted that Niamh's average quantitative score is severely compromised by the fact that she answered only 20 of the 36 questions. This clearly indicates that her quantitative ability is likely to be significantly higher, and in this kind of situation it is essential that teachers identify the cause of the problem before making assumptions about support strategies.

- This is where the *CAT4* profiles can be particularly useful in ensuring that student combinations are supporting both intellectual and social skills development.

Examples of strategies for an extreme verbal bias profile

When a student's verbal reasoning is very much higher than their spatial ability it is likely that reading extensively and from a wide range of material will play to their strengths and help improve their reasoning skills more generally.

Supporting advanced reading skills

Evidence from science, technology, economics, public policy, culture and education shows that an initial advantage enables people to continue to gain further advantages over their peers. In terms of reading, Rigney notes:

> *While good readers gain new skills very rapidly, and quickly move from learning to read to reading to learn, poor readers become increasingly frustrated with the act of reading, and try to avoid reading where possible. … students who begin with high-verbal aptitudes find themselves in verbally enriched social environments and have a double advantage.*
>
> Rigney (2010)

It makes good sense, then, for teachers to use the *CAT4* profile scores of different students to create groupings that benefit all learners in a

group, with the aim that, through meaningful activities with clear aims, students become 'word rich'. We can easily endorse Rigney's view that "good readers may choose friends who also read avidly while poor readers seek friends with whom they share other enjoyments". Interaction with word-rich students is likely to have a knock-on effect for those less secure in their spoken language abilities. As Myhill and Fisher pointed out in an Ofsted commissioned report:

> *... spoken language forms a constraint, a ceiling not only on the ability to comprehend but also on the ability to write, beyond which literacy cannot progress.*
>
> Myhill and Fisher (2005)

As teachers, we have a raft of reading skills that we are unlikely to think about very much. Rather like the act of driving a car, after a certain period of time we become 'unconscious competents' at it and can barely remember how we got from one destination to another. Of course, it wasn't always like that (certainly not when we were taking a driving test), and, for many learners in school, reading is much the same. Our own reading fluency as teachers gets in the way of recognising that for some students the effort spent negotiating the meaning of the words can result in a failure to even get to comprehending those bigger questions of audience and purpose.

Thus, it is essential that all teachers are using the same reading strategies to help students deal with texts. We start with skimming and scanning: it should be a whole-school policy that all teachers understand the difference and can be precise in their instructions to students about which to do and when. 'I'd like you to read this passage' is an instruction that may superficially look straightforward. It's useful for teachers to understand, for example, that when we quickly scan a piece of text we need only to actually read a few words before we can work out whether it is, for example, fact or fiction. It's less easy if students haven't built up a repertoire of reading widely and working out how texts achieve their effects. In all subjects, therefore, teachers need to present explicit knowledge about a wide range of texts, their key features and how their structures can be modelled – ideally by the teachers themselves. This ensures that students struggling with their verbal skills are shown precisely how to create these different writing structures, thus leaving them with more time to develop quality content, having mastered the key structural features first.

As indicated above, middle- and high-school leaders and departmental heads may wish to audit their use of a range of cross-curricular text types using a simple template that identifies the key features of some key text types. They can then ask subject teachers when and how often they use them.

It's likely that some key features of even seemingly disparate texts will be common across different subjects. For example, a recipe and a science report may seem to be unlikely bedfellows, but both have very similar features. These include beginning with an aim or goal, followed by a list of what is needed and then clear instructions on the method. Technically, both will be written in chronological order using imperative verbs (mix the milk and flour; warm the test tube) and there may well be illustration for some of the process. There will certainly be a conclusion showing a final serving suggestion for the recipe and comments on whether the science experiment was successful. There are, of course, many significant differences between these two texts, but the understanding that there are shared common elements in both will result in better comprehension of a reading text and a more well-constructed piece of writing as an outcome.

Providing and using lists of these common language features (usually identified at word, sentence and whole-text levels) helps teachers to explicitly share what might have been secret structural knowledge and so 'levels the playing field' for those spatial bias students struggling to see beyond the meaning of a text.

Further, good oral skills *do* transfer into good writing skills: writer Robert Macfarlane has asserted that "every hour spent reading is an hour spent learning to write" and this would appear to hold true according to recent research.

As we have already indicated, the knowledge and understanding students acquire, regardless of the subjects studied while they are at school, is, at various points, assessed through writing. Even reading skills are assessed through a written response. As students get older, this becomes ever more important. The demands on students to do well in written examinations will characterise their level of achievement in all subjects, including those such as dance, drama, art and PE which may not have included assessment of this kind previously.

We also know that students experience more problems with writing than they do with speaking or reading. Attainment measures across the world tend to indicate that writing skills and outcomes lag behind the other language modes. A 20% gap in achievement is typical. There are also differences between boys and girls, with girls usually doing better than boys. The background questionnaire for the 2009 Programme for International Student Assessment (PISA) report contained these two significant pieces of data:

- In all countries, students who enjoy reading the most perform significantly better than students who enjoy reading the least.
- The gender gap in reading engagement has widened, as well as the gender gap in reading performance.

For some countries, the message is even more stark. For example, out of the 32 countries worldwide that took part in the 2000 PISA survey, the achievement difference in reading literacy between students who never read for enjoyment and those who read for an hour or two each day was greater in Australia than in any other country.

Bloom's Taxonomy and higher-order thinking skills

Bloom's Taxonomy of Educational Objectives (1956) will be familiar to most teachers from their initial teacher training courses. Many teachers may be using a version of the Taxonomy in their classrooms to promote higher-order thinking skills. However, as recent research has indicated, the idea that thinking is sequential or hierarchical is problematic. The problem is that both versions of the Taxonomy suggest that these hierarchical processes are both discrete and in a clear order of difficulty, with 'remembering' at the bottom and 'creating' at the top of a pyramid structure.

The first point is to acknowledge that neither versions of Bloom's pyramid were used by Bloom himself. The co-author of the revised Taxonomy made this clear:

> *I believe that the triangular representation was developed in order to indicate that, in the original Taxonomy, the six categories formed a cumulative hierarchy. That is, it was believed by the authors of the original Taxonomy that mastery of each lower category was necessary before moving to the next higher category. For example, you have to comprehend something before you can apply it.*
>
> Anderson (2017)

But, as other writers have indicated, sometimes the hierarchy idea that places knowledge or remembering at the bottom is simply not true. Berger has a good real-world example of how knowledge can actually be the most important skill:

> *There are many learning situations where knowledge/remembering is actually the most important skill (e.g., I would not want to go hunting for mushrooms with someone who has a poor memory of edible and poisonous species). Also, students cannot analyse or evaluate anything if they don't know facts and evidence.*
>
> Berger (2018)

So, there is no clear distinction between lower- and higher-order thinking skills, and the skills are neither discrete nor hierarchical. However, this is not to say that Bloom's Taxonomy has no purpose – indeed, many teachers find the questions that can be generated from

Bloom's nouns/verbs really useful in the classroom to develop their own questioning techniques and remind them to dig deeper: *Can you tell me the main idea in your own words? How does this compare with…? What do you think would happen if…?*

There is one final aspect of the Taxonomy that relates directly to the strategies teachers will be using in the classroom. A learner's journey is not linear in the way the pyramid might suggest. Berger provides some useful examples:

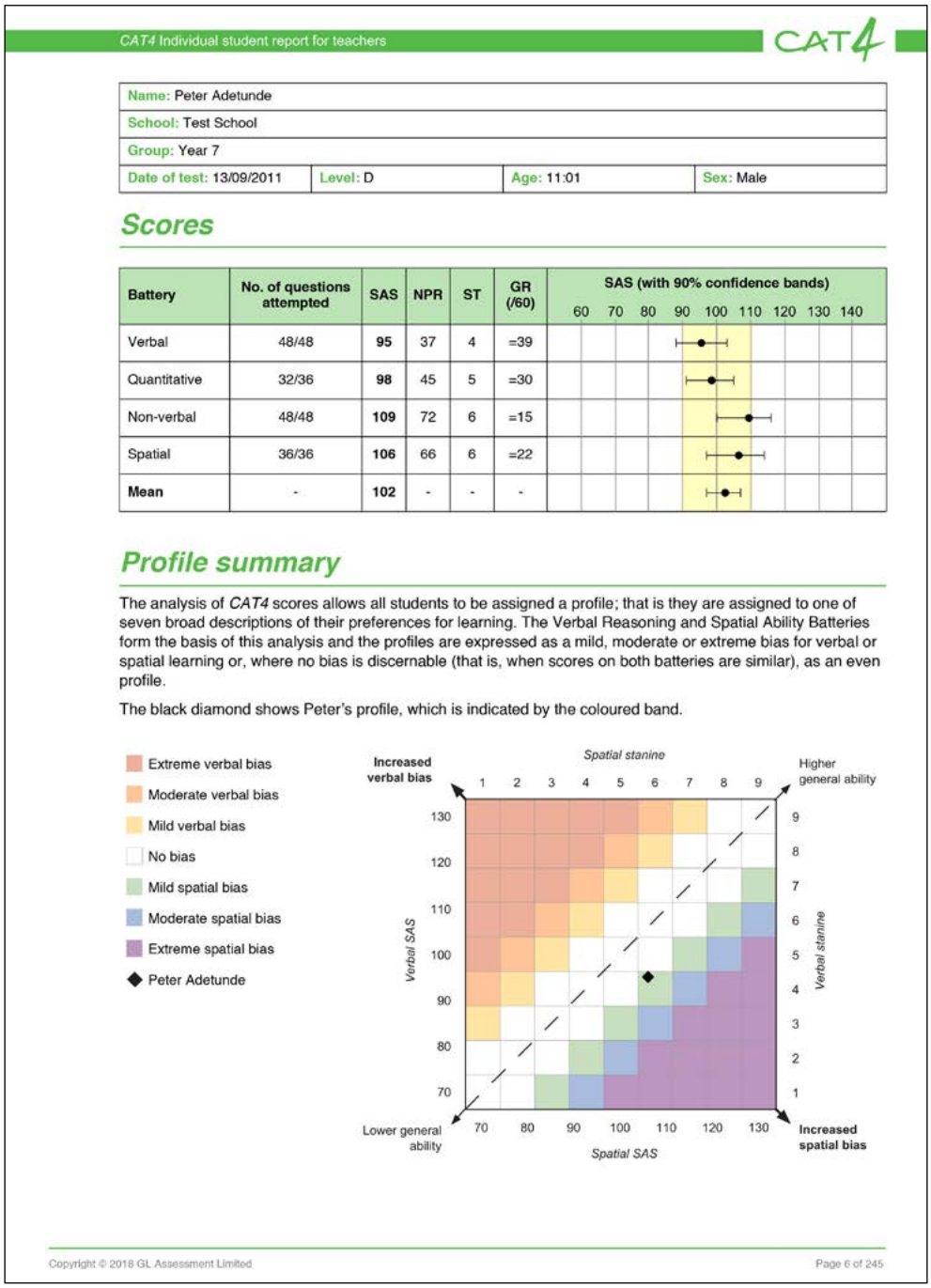
> *When adults set out to learn something new – let's say Spanish, meditation, Adobe Photoshop, or woodworking – we certainly have to learn facts and remember things. But we also quickly realise that we have little understanding until we have actually tried to speak, read, or write Spanish; practice meditation; edit photos; or build a shelf. In other words, we have to apply and create in order to understand. The creation process is where we construct deep understanding.*
>
> *This is the same for our students. We may 'teach' students to write a persuasive essay by having them remember the elements of an essay through a lecture or a rubric. We may assume then that they understand this skill. But I would argue that they have no real understanding of how to write an essay until they have applied their knowledge and created an essay themselves. Additionally, they need to analyse and evaluate the first draft of their essay, along with models of other essays, to build an understanding of what represents quality in that genre so that they can revise and improve. This integrated, circular, iterative process is how learners build understanding.*
>
> Berger (2018)

This is significant and goes back to the understanding about modelling identified earlier by Rosenshine (2012) (see the below average no bias profile of Elena Mazzoni on page 38).

Thus, the emphasis for teachers should not be on what thinking skill to focus on, or how to work from the bottom of the pyramid to the top. Rather, teachers should aim to match the thinking skills and activities chosen with the desired learning outcomes, take into account the information they have gleaned from individual *CAT4* student profiles and use modelling and scaffolding strategies that give students like Niamh Ernst the best opportunity to achieve those outcomes.

Example of a mild spatial bias profile

- Students with a similar bias should perform better when engaged in tasks that require visualisation, and these students should enjoy working with pictures, diagrams, maps and 3D objects.
- Whilst these students are likely to be average or above in the STEM subjects that make the most of their spatial ability, like other students with a spatial bias they may be less confident of success in language-based subjects like English and the humanities.



CAT4 Individual student report for teachers

CAT4

Name: Peter Adetunde			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	**Level:** D	**Age:** 11:01	**Sex:** Male

Scores

Battery	No. of questions attempted	SAS	NPR	ST	GR (/60)	SAS (with 90% confidence bands) 60 70 80 90 100 110 120 130 140
Verbal	48/48	**95**	37	4	=39	
Quantitative	32/36	**98**	45	5	=30	
Non-verbal	48/48	**109**	72	6	=15	
Spatial	36/36	**106**	66	6	=22	
Mean	-	**102**	-	-	-	

Profile summary

The analysis of *CAT4* scores allows all students to be assigned a profile; that is they are assigned to one of seven broad descriptions of their preferences for learning. The Verbal Reasoning and Spatial Ability Batteries form the basis of this analysis and the profiles are expressed as a mild, moderate or extreme bias for verbal or spatial learning or, where no bias is discernable (that is, when scores on both batteries are similar), as an even profile.

The black diamond shows Peter's profile, which is indicated by the coloured band.

Extreme verbal bias
Moderate verbal bias
Mild verbal bias
No bias
Mild spatial bias
Moderate spatial bias
Extreme spatial bias
Peter Adetunde

Increased verbal bias
Spatial stanine
Higher general ability
1 2 3 4 5 6 7 8 9
130 120 110 100 90 80 70
Verbal SAS
Verbal stanine
9 8 7 6 5 4 3 2 1
Lower general ability
70 80 90 100 110 120 130
Spatial SAS
Increased spatial bias

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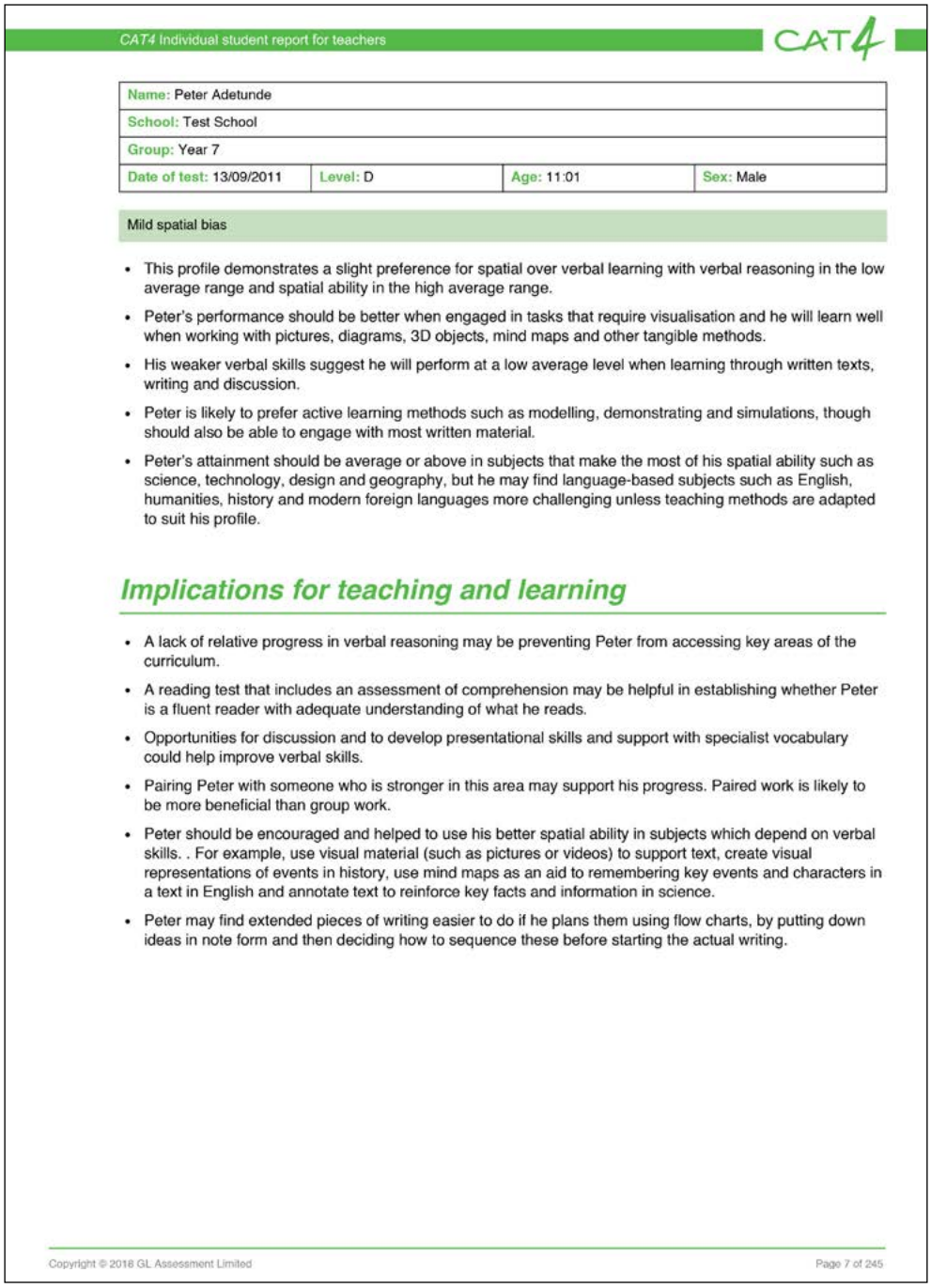


CAT4 Individual student report for teachers

CAT4

Name: Peter Adetunde			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	**Level:** D	**Age:** 11:01	**Sex:** Male

Mild spatial bias

- This profile demonstrates a slight preference for spatial over verbal learning with verbal reasoning in the low average range and spatial ability in the high average range.
- Peter's performance should be better when engaged in tasks that require visualisation and he will learn well when working with pictures, diagrams, 3D objects, mind maps and other tangible methods.
- His weaker verbal skills suggest he will perform at a low average level when learning through written texts, writing and discussion.
- Peter is likely to prefer active learning methods such as modelling, demonstrating and simulations, though should also be able to engage with most written material.
- Peter's attainment should be average or above in subjects that make the most of his spatial ability such as science, technology, design and geography, but he may find language-based subjects such as English, humanities, history and modern foreign languages more challenging unless teaching methods are adapted to suit his profile.

Implications for teaching and learning

- A lack of relative progress in verbal reasoning may be preventing Peter from accessing key areas of the curriculum.
- A reading test that includes an assessment of comprehension may be helpful in establishing whether Peter is a fluent reader with adequate understanding of what he reads.
- Opportunities for discussion and to develop presentational skills and support with specialist vocabulary could help improve verbal skills.
- Pairing Peter with someone who is stronger in this area may support his progress. Paired work is likely to be more beneficial than group work.
- Peter should be encouraged and helped to use his better spatial ability in subjects which depend on verbal skills. . For example, use visual material (such as pictures or videos) to support text, create visual representations of events in history, use mind maps as an aid to remembering key events and characters in a text in English and annotate text to reinforce key facts and information in science.
- Peter may find extended pieces of writing easier to do if he plans them using flow charts, by putting down ideas in note form and then deciding how to sequence these before starting the actual writing.

Peter Adetunde has a slight preference for spatial over verbal learning. His verbal reasoning score of 95 is in the low average range while his spatial ability score of 106 is in the high average range. Peter should be encouraged and helped to use his better spatial ability in subjects that depend on verbal skills. For example, Peter could use visual material to support text, create pictorial or diagrammatic representations of events in history and use mind maps to help remember key events and characters in a text in English.

With a verbal score of 95, Peter may not need the same kind of extensive language screening support as a student with a moderate spatial bias, such as Romana Kudayamage (see profile on page 81), but instead teachers should use his strong spatial and non-verbal skills to support those areas where his comprehension skills are lacking.

What does this look like in the classroom?

For students with English as an additional language (EAL), the low score on the Verbal Reasoning Battery may indicate a lack of fluency with the English language.

- The important factor here is not whether the student speaks English as an additional language, but the student's level of fluency in reading English. Many students with EAL are fully fluent both in their home language and in English; these fluent bilingual students can have a level of performance in the verbal domain that exceeds the average for monolingual English speakers (Strand, 1995).
- Where students have EAL and are not fluent in reading English, it is advisable to consider the mean score excluding the verbal score. This may be more informative about the student's cognitive abilities. Expectations for such students' subsequent learning and achievement in tests or examinations needs to be appropriately

high. This assumes that the student's language learning needs are recognised and effectively resourced and addressed.

- Where the student is a non-native English speaker, it is important to assess the extent of their reading skills. As a quick check, teachers should try reading some of the questions aloud to the student. Does the student's performance improve markedly? If so, and if the student has persistent and ongoing problems at word level (as distinct from sentence or text level), he or she may have a specific reading difficulty. Teachers may want to consider one-to-one diagnostic assessment to more fully determine the student's needs (see above). Most importantly, the student should be observed carefully in different contexts and when undertaking a range of activities.

It is also possible that the **low verbal score might reflect social and economic disadvantages**, such as little exposure to rich and varied language in the home or wider environment.

- Whatever the cause of the poor verbal performance, it is vitally important that it is addressed. This is because verbal skills are so central to success in learning at school.

One key to Peter's continuing achievement is likely to be the role played by **effective collaboration with other students**.

- Peter's attitude to learning is likely to be influenced by his relatively poor verbal skills and so the opportunity to work with a more fluent partner will pay dividends.
- As noted previously, teachers should avoid students working in groups of three where one student is likely to become a 'passenger' while the other two engage in animated conversation. Instead, devising short, dynamic pair activities will support Peter's learning and social skills.
- As with any student, giving Peter a clearly defined role in group work will develop his strengths and support in his weaknesses. In pair work, the teacher may choose a partner with stronger verbal skills to support his progress.

As well as addressing specific individual issues, there is also much that can be done to **support reading development across the curriculum** for all students, ensuring that they are able to make progress in their learning because they have the required reading skills. Examples of specific strategies are provided below. These will be covered under the guidance for moderate spatial bias – see Romana Kudayamage's profile.

Examples of strategies for a mild spatial bias profile

The following strategies will support learners with a mild spatial bias profile.

1. Addressing EAL and verbal issues

The percentage of students aged 5-16 in England's schools who are recorded as EAL has more than doubled from 7.6% in 1997 to 16.2% in 2013, and so identifying language learning needs is more important than ever, whether in a UK or international school context.

As noted, recording EAL in England often means a student has a low level of English language proficiency, or is from a home background where English language is not used. These students are likely to have lower achievement when starting school, but this effect "reduces markedly with age and is essentially eliminated by age 16" (Strand et al, 2015). In some measures of achievement in England, EAL students outperform their first-language-English peers.

Presuming that students in the UK make the expected journey through English language acquisition, scores across the batteries might be expected to improve. As noted already, students tend to receive a less extreme bias profile if they are tested two years later, and this is true both for EAL and first-language-English students.

This is not necessarily true for international schools that use English as the medium of instruction but which are located in a country that does not use the English language much outside of the school. Data from these contexts are sparse and often the school populations do not resemble the countries' make-up of nationalities or socio-economic status. However, it is likely that students learning English in these contexts make less progress since there is less exposure to the language outside of school, so differences in achievement may persist to a greater extent, and differences in *CAT4* scores persist also. Spatial bias is a more common profile in these conditions than in the UK, and this reflects the level of vocabulary required to score highly on the *CAT4* Verbal Reasoning Battery.

Where a school has a special educational needs co-ordinator (SENCo) or someone with this responsibility, they should be able to determine the reading interventions required for specific support.

2. Addressing dyslexia and verbal issues

Low-scoring students may have been held back by a specific reading difficulty. Although dyslexia is not conceptualised as a problem with verbal reasoning, and indeed many researchers have found that dyslexia is equally common across the spectrum of abilities, it might be that very poor reading skills have affected a student's performance on *CAT4*.

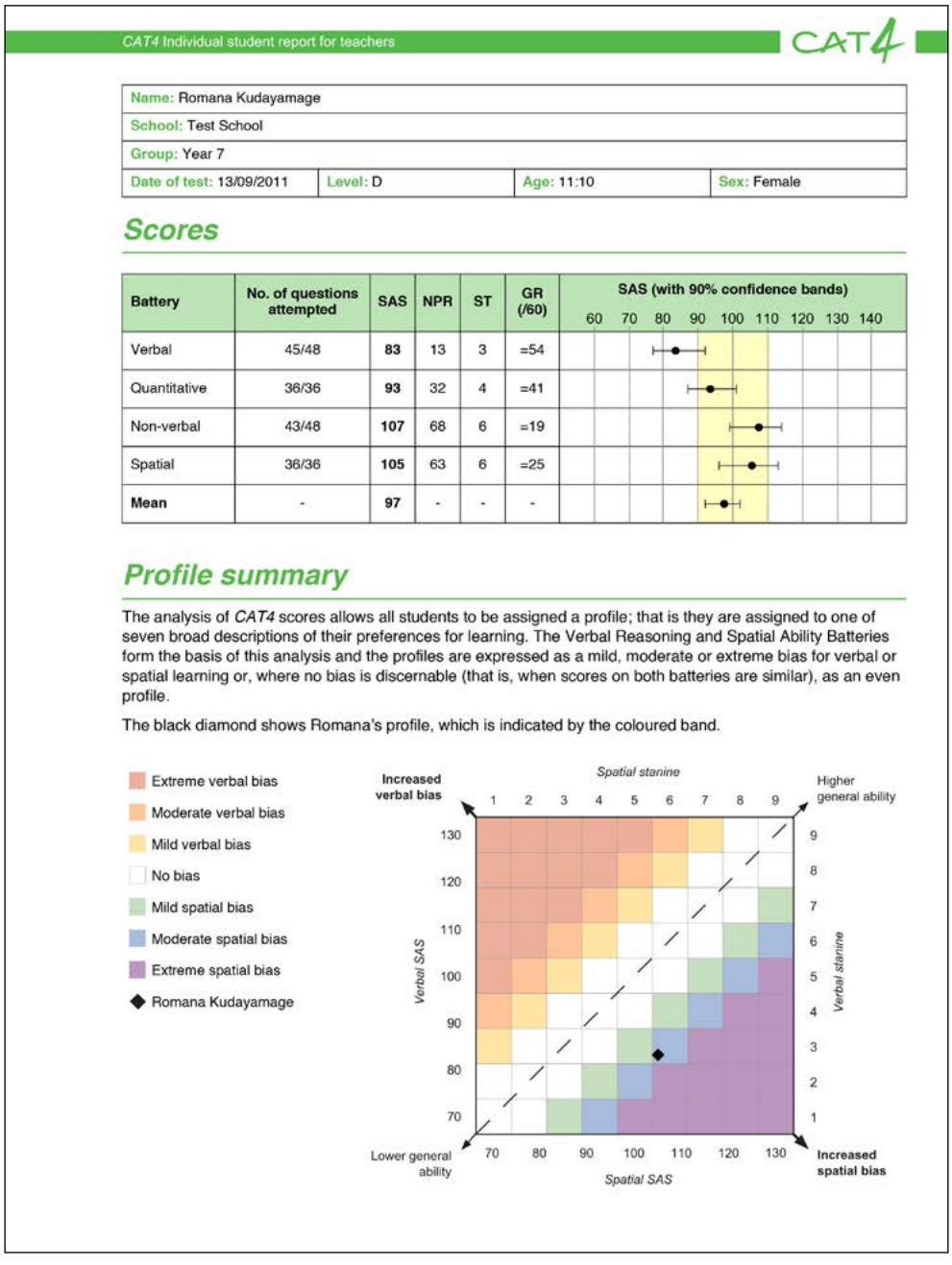
Dyslexia usually presents as a deficit of processing written words into their component sounds, which can take up the working memory, leading to worse outcomes whenever learning or reasoning involves written words.

It is important for teachers to check whether any spatial bias students have not answered all of the questions in the Verbal Battery, and, if not, then it might be that the teacher can identify whether readability or comprehension (or both) are issues. If the student is readily able to answer test questions when presented orally then the issue is clear, and the teacher may wish to administer *CAT4* with adjusted conditions, particularly if it is likely that adjusted conditions will usually be allowed in the classroom and exam hall.

Along with GL Assessment's diagnostic tools for identifying dyslexic tendencies, there is also the *Dyslexia Guidance*, which is specialised for students who are suspected of having specific learning difficulties with reading. The *Dyslexia Guidance* also includes resources to assist those students struggling with specific reading difficulties, whether formally diagnosed or not.

Example of a moderate spatial bias profile

- Students with a moderate spatial bias exhibit a relative strength in spatial over verbal learning.
- Moderate spatial bias students' performance is likely to be better when they are engaged in tasks that require visualisation – including working with pictures, diagrams, maps and 3D objects.
- While national assessments in secondary education are likely to reflect their verbal abilities rather than their spatial abilities, students with a spatial bias might be drawn to STEM subjects that make the most of spatial ability and are less text heavy.



CAT4 Individual student report for teachers

CAT4

Name: Romana Kudayamage			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	Level: D	Age: 11:10	Sex: Female

Scores

Battery	No. of questions attempted	SAS	NPR	ST	GR (/60)	SAS (with 90% confidence bands) 60 70 80 90 100 110 120 130 140
Verbal	45/48	**83**	13	3	=54	
Quantitative	36/36	**93**	32	4	=41	
Non-verbal	43/48	**107**	68	6	=19	
Spatial	36/36	**105**	63	6	=25	
Mean	-	**97**	-	-	-	

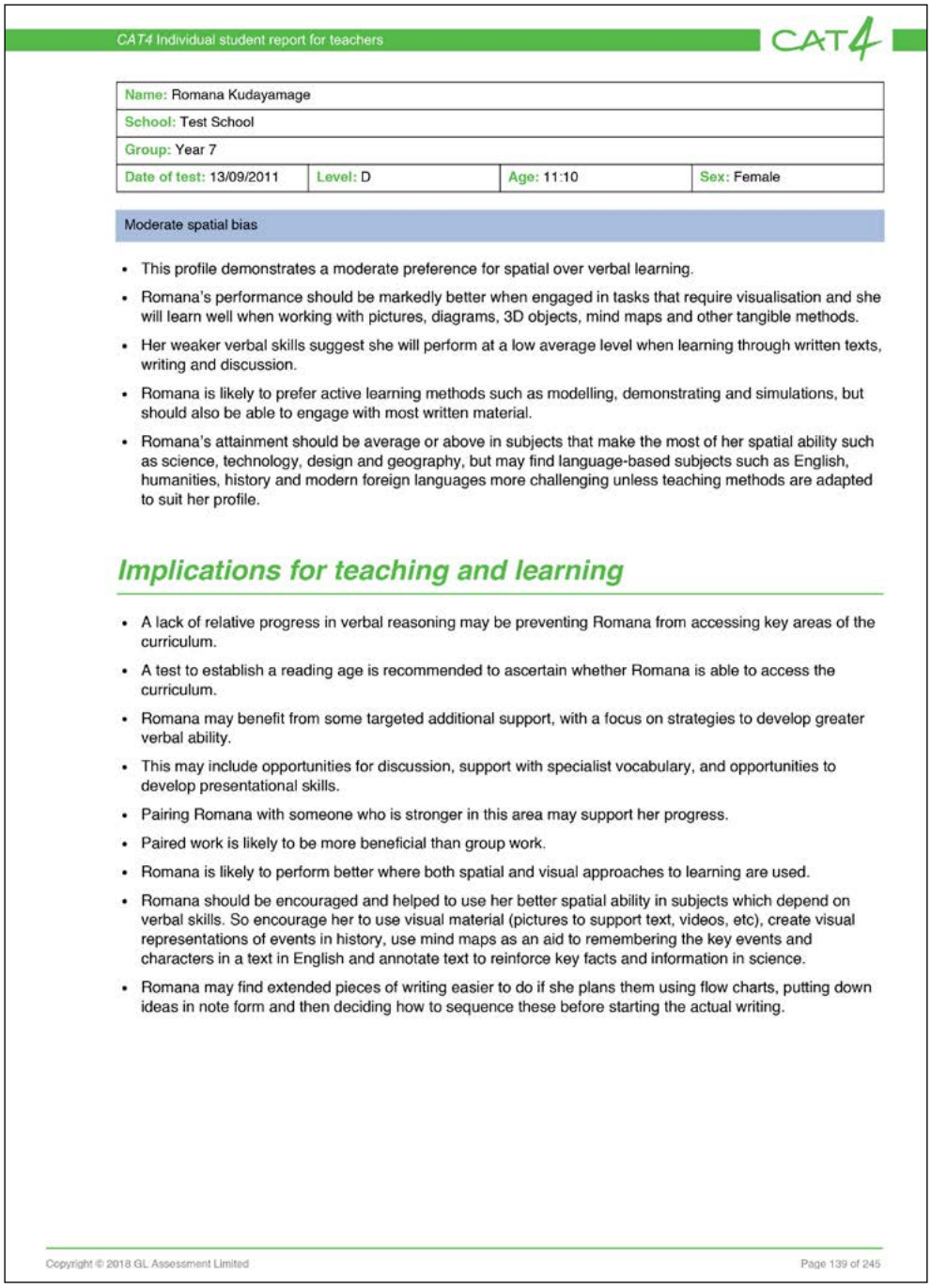
Profile summary

The analysis of *CAT4* scores allows all students to be assigned a profile; that is they are assigned to one of seven broad descriptions of their preferences for learning. The Verbal Reasoning and Spatial Ability Batteries form the basis of this analysis and the profiles are expressed as a mild, moderate or extreme bias for verbal or spatial learning or, where no bias is discernable (that is, when scores on both batteries are similar), as an even profile.

The black diamond shows Romana's profile, which is indicated by the coloured band.

Extreme verbal bias
Moderate verbal bias
Mild verbal bias
No bias
Mild spatial bias
Moderate spatial bias
Extreme spatial bias
Romana Kudayamage

Increased verbal bias
Spatial stanine
1 2 3 4 5 6 7 8 9
Higher general ability
130 120 110 100 90 80 70
Verbal SAS
9 8 7 6 5 4 3 2 1
Verbal stanine
Lower general ability
70 80 90 100 110 120 130
Increased spatial bias
Spatial SAS



CAT4 Individual student report for teachers

CAT4

Name: Romana Kudayamage			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	**Level:** D	**Age:** 11:10	**Sex:** Female

Moderate spatial bias

- This profile demonstrates a moderate preference for spatial over verbal learning.
- Romana's performance should be markedly better when engaged in tasks that require visualisation and she will learn well when working with pictures, diagrams, 3D objects, mind maps and other tangible methods.
- Her weaker verbal skills suggest she will perform at a low average level when learning through written texts, writing and discussion.
- Romana is likely to prefer active learning methods such as modelling, demonstrating and simulations, but should also be able to engage with most written material.
- Romana's attainment should be average or above in subjects that make the most of her spatial ability such as science, technology, design and geography, but may find language-based subjects such as English, humanities, history and modern foreign languages more challenging unless teaching methods are adapted to suit her profile.

Implications for teaching and learning

- A lack of relative progress in verbal reasoning may be preventing Romana from accessing key areas of the curriculum.
- A test to establish a reading age is recommended to ascertain whether Romana is able to access the curriculum.
- Romana may benefit from some targeted additional support, with a focus on strategies to develop greater verbal ability.
- This may include opportunities for discussion, support with specialist vocabulary, and opportunities to develop presentational skills.
- Pairing Romana with someone who is stronger in this area may support her progress.
- Paired work is likely to be more beneficial than group work.
- Romana is likely to perform better where both spatial and visual approaches to learning are used.
- Romana should be encouraged and helped to use her better spatial ability in subjects which depend on verbal skills. So encourage her to use visual material (pictures to support text, videos, etc), create visual representations of events in history, use mind maps as an aid to remembering the key events and characters in a text in English and annotate text to reinforce key facts and information in science.
- Romana may find extended pieces of writing easier to do if she plans them using flow charts, putting down ideas in note form and then deciding how to sequence these before starting the actual writing.

Romana's moderate spatial bias profile and strength in spatial learning is countered by a significantly low verbal score of 83, and so early identification of whether additional language support is required is essential. A diagnostic test such as GL's Dyslexia Screener should be the starting point for an evaluation of her needs.

As well as addressing specific individual issues, there is also much that can be done to **support reading development across the curriculum** for all students, ensuring that they are able to make progress in their learning because they have the required reading skills. Examples of specific strategies are provided below.

- As learning moves through the middle-school to the high-school phase, the subject-specific language demands become much more challenging for many students. Crucially, teachers need to ensure that this key conceptual and technical vocabulary is learned and applied, which means that teachers must ensure that students are hearing, recording, learning and then using these new words in their work.
- This requires that students are engaged in active ways that lodge these words and concepts in their memories. As Sherrington (2017) notes, teachers will "often find students who are not confident saying a word out loud even when it is one they encounter frequently at school". This is his list of such words: remarkable, spontaneous, extraordinary, photosynthesis, decomposition, denominator, transformation, confrontation, specific, accommodation, commendation, appropriate, reflection.

As noted earlier, the distance between being 'word rich' and 'word poor' for students like Romana can be a crippling disadvantage long before external examinations become important. Thus, making all teachers aware of the cross-curricular language challenges she is likely to face is essential.

EAL students who appear to have a mild, moderate or extreme spatial bias often actually have suppressed verbal scores which will develop with the acquisition of the English language. For further help and insight please go to page 77.

What does this look like in the classroom?

Moderate spatial bias students, particularly if they have lower than average verbal reasoning scores, are **likely to require more support in developing language skills**.

- This requires that teachers have a clear understanding of the language demands of their subject area and that common strategies are used to help students like Romana negotiate their way through the reading challenges they will face.
- Devising a simple audit for the most commonly used text types across the curriculum is a straightforward way to do this. Once all teachers have completed the audit for their subject, they can then be provided with some basic guidance to encourage them to refer to common features of the most frequently used texts. Examples of this approach are given below.

Examples of strategies for a moderate spatial bias profile

A strong body of evidence from research has identified the benefits of targeted reading comprehension strategies. Early intervention is often better than late intervention, particularly when increased automatism of reading skills can lead to freeing up the working memory for other tasks such as new learning, leading to the cumulative advantage.

1. Developing reading skills

It is important for teachers of all subjects to ensure that active strategies enabling students to develop their reading skills are used across the curriculum. It is important now for teachers to use a repertoire of cross-curricular strategies to improve, sustain and deepen reading abilities.

The starting point for any teacher should be an evaluation of the reading demands of their subject or phase, as well as the reading abilities of their class. This means thinking carefully about how students encounter texts (for example, in subject textbooks and worksheets) and how teachers manage the verbal workload (for example, by clear layout and the use of bullet points and columns; through specialist vocabulary lists and appropriate definitions).

Good readers are fluent readers, but this skill does not simply appear. It needs to be developed, practised and sustained. We can break down reading into several parts: the technical aspects of reading, and reading a passage for deep comprehension. We will then cover the key skills of skimming and scanning, and move on to how teachers can establish a reading culture.

Firstly, the technical aspects can be developed without a text to read. For example, choosing a reading activity as a lesson starter will ensure that reluctant or EAL readers are able to achieve some success in the first five minutes of a lesson. Some popular examples, some of which have been taken from https://www.thegrid.org.uk, are listed below:

- Students match word cards with definition cards. This can be done as a card-sort or snap game.
- Students write dictionary definitions or mnemonics for new words/terms/concepts learned in the last lesson.
- Students identify from anagrams the key words/terms/concepts to feature in today's lesson.
- Bingo: as the teacher reads, students must spot a word/symbol and mark their bingo card.
- Dominoes: students match a symbol/image/definition with a key word.
- Pictionary: students draw a picture representing a word or phrase chosen by the teacher. Other students guess the word or phrase.

- Students are given a wordsearch containing key words or information useful in the lesson (which can also provide clues/definitions to activate prior knowledge). See www.puzzlemaker.com for models.
- Students break a code to identify three main words/terms/concepts of today's lesson (a=b, b=c and so on).

Secondly, when reading texts, it is important to go beyond the text itself. The usual method used by teachers to check student understanding of any new text is to ask questions, but this is not the only way. Where teachers in any subject develop their repertoire of supporting activities, students are likely to feel more confident and teachers can be reassured that understanding has taken place. Appropriate strategies could include:

- Students work in pairs with a cloze exercise in which key words are missing.
- Paragraphs or sentences are presented in the wrong order and students have to work out the correct structure.
- Students are required to draw and label a diagram/picture that sums up the meaning of a key concept.
- Students work in groups of four to predict what will come next in a section of text.

Teachers could use short, direct, engaging pieces of text and directly model their responses to some generic key questions: *Who is the text written for? What layout features can I see without reading any words and what do these tell me? What do I think is the writer's attitude to his/her subject?*

Working with the students, and asking them to work in pairs, the teacher can then work through simpler (but often more challenging) questions: *Who, What, When, Where, How* and *Why.* Teachers should follow this up by encouraging students to predict using the text: *What do you think Frankenstein will do next? What do you think he feels about creating the monster?* Teachers should model responses first if necessary.

With more responses comes deeper understanding, and once students begin to see the rewards of their efforts they are more likely to continue the process themselves.

2. Skimming and scanning

Skills such as skim reading (getting the gist of the text) and scanning (looking for specific information) should not be overlooked by teachers interested in developing reading skills. Because teachers tend to do much of this text interrogation instinctively, it's important to externalise this process for students. It's easy to say skim read, but, like all strategies, it needs to be explained and practised.

An easy way to do this is to ask some key questions. For example, *What kind of text does this look like? Who is it aimed at? How is it structured?* (and, for some texts, *When do you think it was written?*). Here, the aim is to quickly build an understanding at text level, rather than word level or sentence level.

For example, the general rule of a series of reading comprehension exercises is that the answer to Question 2 will generally be found after the answer to Question 1 but before the answer to Question 3. This is likely to be self-evident to teachers but not necessarily to some students, particularly those whose working memory has been used up in the process of reading such that they cannot notice wider patterns.

3. Establishing a reading culture

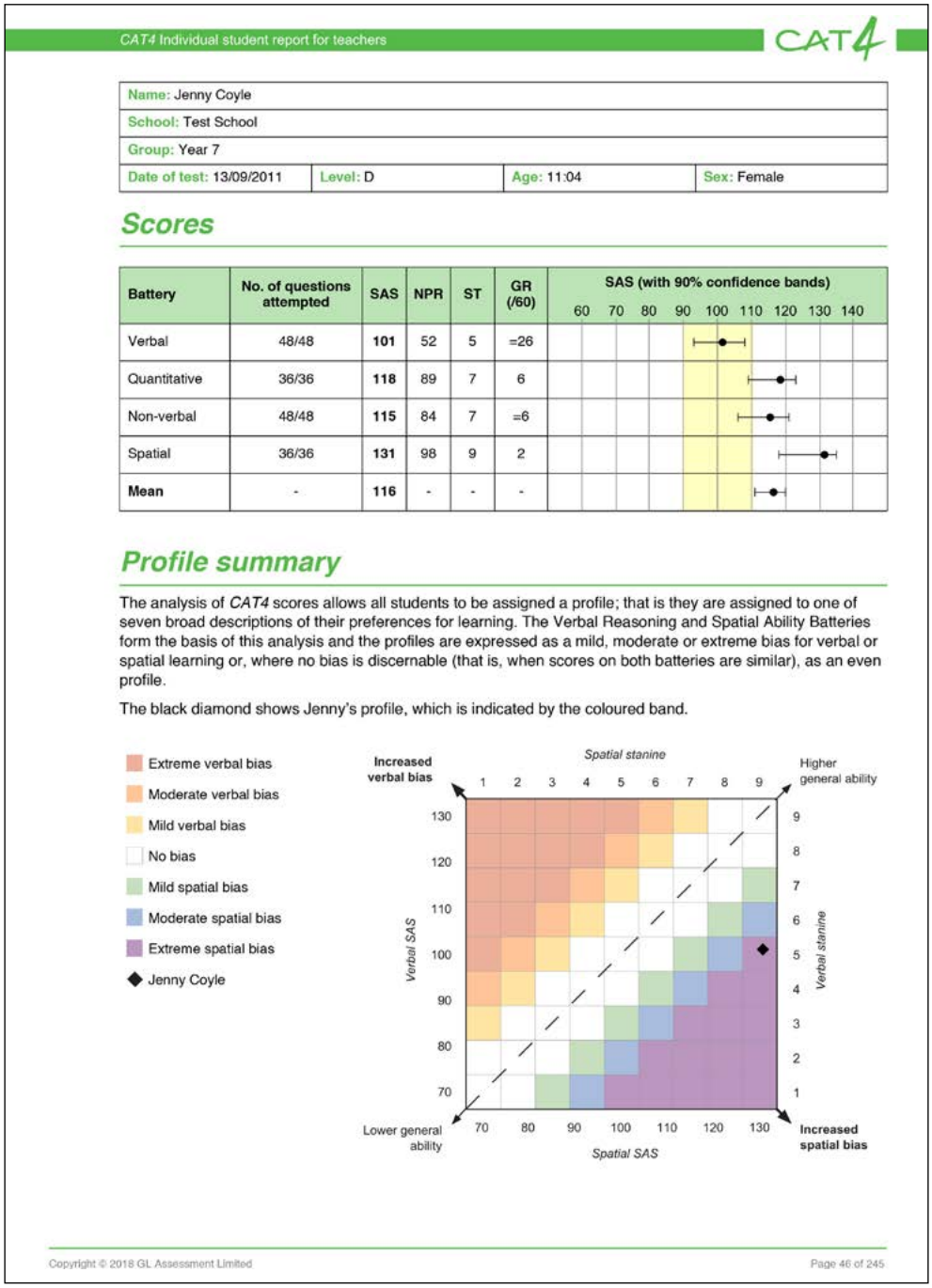
More widely, establishing a reading culture across the school is a key way to support less secure readers because it places teachers *within* the reading process, making them active participants in the act of reading. Therefore, it is *essential* for teachers to be seen to read themselves (for pleasure and to develop subject knowledge); to be confidently reading aloud in class and enjoying the process; to be actively researching meanings and derivations; to be checking their own spelling with a dictionary or an online tool; and, perhaps most importantly, to be modelling any of the strategies they find effective in decoding and understanding texts.

This relates to the idea of rehearsal after a class, that we have touched upon previously.

Example of an extreme spatial bias profile

- Students with this profile have a distinct strength in spatial over verbal reasoning.

- These students should excel when engaged in tasks that require visualisation and will learn quickly when working with pictures, diagrams, 3D objects, mind maps and other tangible methods.
- Their relatively weaker verbal skills may make learning through written texts, writing and discussion less effective. Suggested strategies to support this are provided below.
- Interestingly, students with these profiles are often characterised as 'intuitive' and capable of seeing 'the big picture', but this may be at the expense of a lack of attention to detail, which can be a characteristic of such students.



CAT4 Individual student report for teachers

CAT4

Name: Jenny Coyle			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	**Level:** D	**Age:** 11:04	**Sex:** Female

Scores

Battery	No. of questions attempted	SAS	NPR	ST	GR (/60)	SAS (with 90% confidence bands) 60 70 80 90 100 110 120 130 140
Verbal	48/48	**101**	52	5	=26	
Quantitative	36/36	**118**	89	7	6	
Non-verbal	48/48	**115**	84	7	=6	
Spatial	36/36	**131**	98	9	2	
Mean	-	**116**	-	-	-	

Profile summary

The analysis of *CAT4* scores allows all students to be assigned a profile; that is they are assigned to one of seven broad descriptions of their preferences for learning. The Verbal Reasoning and Spatial Ability Batteries form the basis of this analysis and the profiles are expressed as a mild, moderate or extreme bias for verbal or spatial learning or, where no bias is discernable (that is, when scores on both batteries are similar), as an even profile.

The black diamond shows Jenny's profile, which is indicated by the coloured band.

Extreme verbal bias
Moderate verbal bias
Mild verbal bias
No bias
Mild spatial bias
Moderate spatial bias
Extreme spatial bias
Jenny Coyle

Spatial stanine
Increased verbal bias
Higher general ability
Verbal SAS
Verbal stanine
Lower general ability
Increased spatial bias
Spatial SAS

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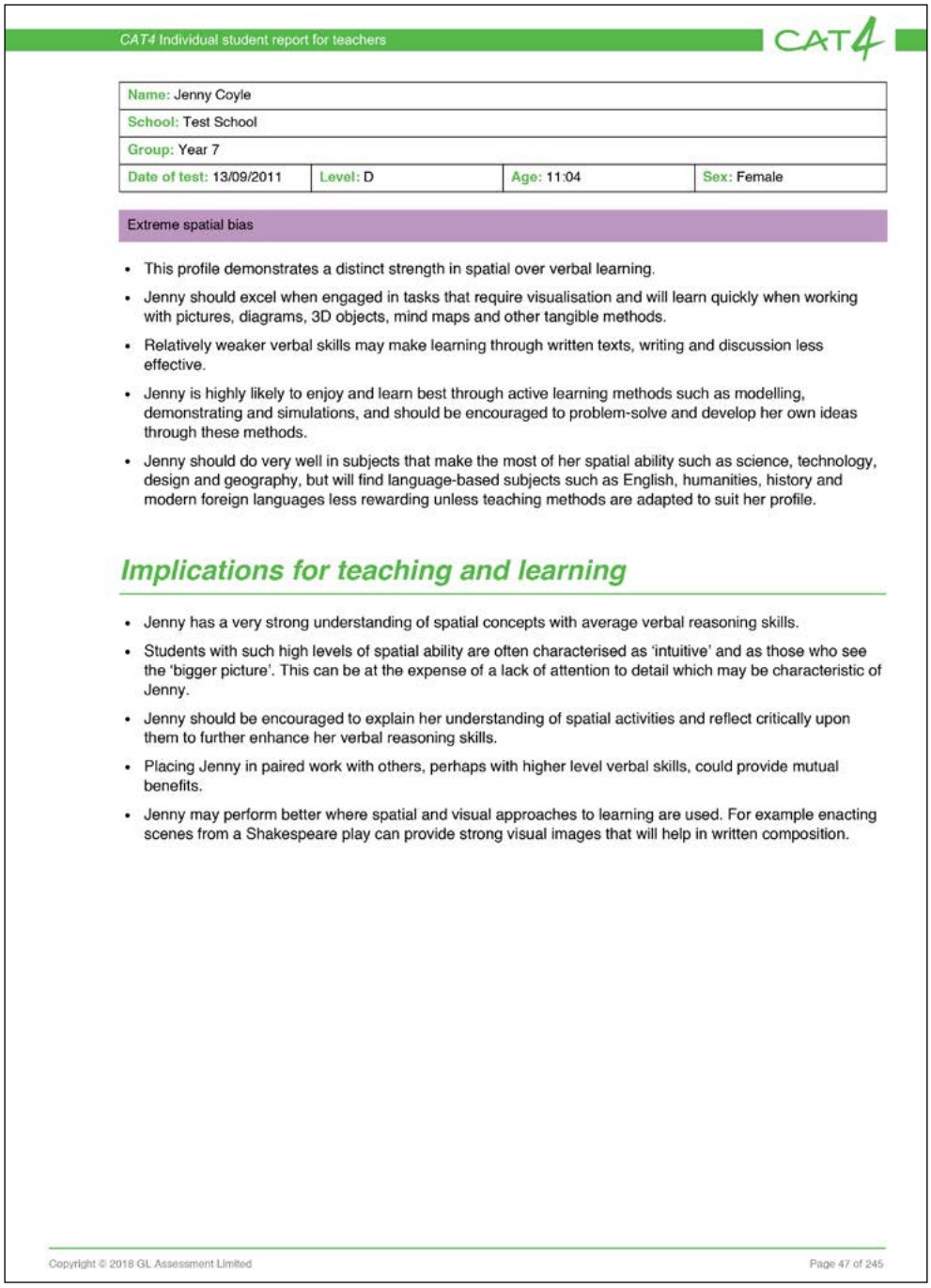


CAT4 Individual student report for teachers

CAT4

Name: Jenny Coyle			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	**Level:** D	**Age:** 11:04	**Sex:** Female

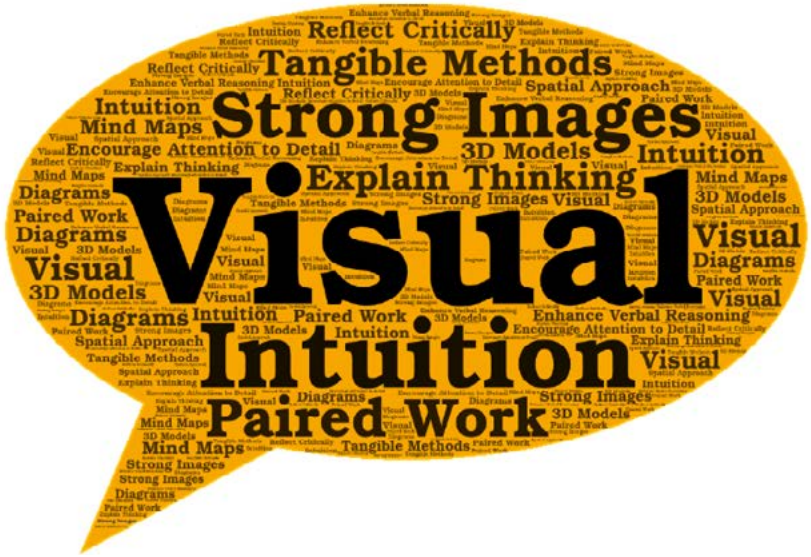
Extreme spatial bias

- This profile demonstrates a distinct strength in spatial over verbal learning.
- Jenny should excel when engaged in tasks that require visualisation and will learn quickly when working with pictures, diagrams, 3D objects, mind maps and other tangible methods.
- Relatively weaker verbal skills may make learning through written texts, writing and discussion less effective.
- Jenny is highly likely to enjoy and learn best through active learning methods such as modelling, demonstrating and simulations, and should be encouraged to problem-solve and develop her own ideas through these methods.
- Jenny should do very well in subjects that make the most of her spatial ability such as science, technology, design and geography, but will find language-based subjects such as English, humanities, history and modern foreign languages less rewarding unless teaching methods are adapted to suit her profile.

Implications for teaching and learning

- Jenny has a very strong understanding of spatial concepts with average verbal reasoning skills.
- Students with such high levels of spatial ability are often characterised as 'intuitive' and as those who see the 'bigger picture'. This can be at the expense of a lack of attention to detail which may be characteristic of Jenny.
- Jenny should be encouraged to explain her understanding of spatial activities and reflect critically upon them to further enhance her verbal reasoning skills.
- Placing Jenny in paired work with others, perhaps with higher level verbal skills, could provide mutual benefits.
- Jenny may perform better where spatial and visual approaches to learning are used. For example enacting scenes from a Shakespeare play can provide strong visual images that will help in written composition.

Jenny Coyle's extreme spatial bias profile is countered by a quantitative score of 118 and a non-verbal score of 115. It's important to use this student's strengths in the quantitative, non-verbal and spatial areas to scaffold what is a relative verbal weakness (101). However, and as we have previously identified, verbal ability is so crucial to academic success that interventions to directly address any verbal weaknesses can dramatically improve results.



What does this look like in the classroom?

Early identification and appropriate provision for extreme spatial bias students like Jenny is likely to make a significant difference to their progress in STEM subjects, and more generally across the curriculum.

- Through the use of real and virtual technology, STEM subjects in high school are increasingly explored through different media and dimensions – whether it's understanding a key scientific concept like DNA, using Computer Aided Design (CAD) tools to design a roller-coaster or negotiating the frontiers of modern physics.
- Once a test has identified this strength, it will be important for teachers to challenge and stretch such students to take forward their spatial skills and integrate them into their learning.
- However, spatial ability is not a kind of learning style and, as with all students, it would be wrong to label a student as having a preference that must be acknowledged and used.
- An increasing amount of research evidence indicates that as learners we can even develop our spatial skills. Students who can crack the spatial code of a Rubik's Cube or who relax with a game of Tetris are actively demonstrating that this was not a skill they were born with but rather one that they have honed over long hours of practice.

- Further, research has indicated that such apparently limited skills are transferrable and that spatial training impacts on many areas of learning.

Closely linked to spatial skills is the ability to think analogically, that is, to see relational similarities between one situation and another, for example the structure of an atom and the way in which our solar system works.

- Evidence suggests that this ability helps to develop mathematical insight and scientific reasoning.
- Teachers need to be aware of how they can develop these abilities even in the primary years. For example, drawing maps, using a wide range of positional words (underneath, inside out, upside down) and completing jigsaws both help to extend spatial skills.

Like most extreme spatial bias learners, Jenny is very much the kind of student who **will benefit from a highly visual start to any lesson**.

- If Jenny is quickly engaged and actively involved in, for example, a visual challenge that makes the most of her STEM-related skills then she will maintain her motivation to learn.
- A good example of this kind of approach is the concept cartoon described in the next section – a challenge for young learners to think about – and this example below is one of the most well-known.

Jenny's profile indicates that she is **highly likely to enjoy and learn best through active learning methods**, including simulations, problem-solving activities and the creation of original ideas and responses to new learning.

- These active learning activities may involve using and creating strong visual images through creative activities.

Finally, it should be noted that students with an extreme spatial bias can be invaluable in some group-work situations. Whilst their verbal skills are less developed, their ability to quickly visualise a solution, see a pattern or draw conclusions from a range of disparate sources makes them invaluable in groups.

EAL students who appear to have a mild, moderate, or extreme spatial bias often actually have suppressed verbal scores which will develop with their acquisition of the English language. For further help and insight please go to page 77.

Examples of strategies for an extreme spatial bias profile

These strategies will be helpful in enabling extreme spatial bias learners to perform at their best.

1. Effective lesson starters

As indicated above, the principle of the lesson starter is an important aspect of classroom management. It's all about setting the tone of the lesson. The five-minute starter (it is rarely useful to have one that is any longer than this) is all about signalling a series of expectations: how students are expected to interact with each other, the processes of learning that will take place, and establishing key classroom management rules and routines.

The key reason for having a starter is to hook students into the learning; to make all of them feel that they have learned something in those vital first five minutes. In doing this, teachers also need to create an opportunity for students to think about something specific and manageable.

For extreme spatial bias students, visual starters are going to be most effective. Any of the five examples below will ensure that students feel engaged, motivated and ready to learn more as the lesson progresses.

- Concept cartoon: students choose from speech-bubble opinions of different characters and identify which one they think is closest to the truth, giving reasons for their view.
- Prediction: students are asked *What will happen if…?* about a current issue, presented in a single still image. Teachers should give them one minute to compose an oral reply and they must give reasons for their response.
- Objects: students are given a group of objects and asked to sort/imaginedescribe/predict/explain/plan an activity. The objects can be as imaginative as the teacher wishes – the aim is to generate creative responses.
- The teacher shows a very short video extract which students then consider in pairs: What do I already know? What did I learn from the extract? What do I want to find out?
- Painting/musical stimulus: students respond to a powerful painting or a short piece of music and then shape an initial response in writing, in a drawing or orally. Additional vocabulary to support a more detailed written or oral response can be provided by the teacher if required.

Teachers may wish to use the excellent archive from the British *Guardian* newspaper at www.guardian.co.uk/world/series/eyewitness or the unparalleled resource that is the *National Geographic* magazine at www.nationalgeographic.com.

Concept Cartoons were created by Brenda Keogh and Stuart Naylor in 1991 and feature cartoon-style drawings showing different characters discussing an everyday situation that encourages learners to do the same. They are particularly appropriate for students with an extreme spatial bias as they represent key ideas in an entirely visual way with minimal text, and usually offering alternative viewpoints that prompt discussion. Presenting a concept cartoon as a five-minute activity is a good way to begin a science lesson and ensures that even reluctant learners benefit, including those like Jenny who may have excellent spatial skills but are limited in some other aspects of their learning.

2. Using visual images and drama

An extreme spatial bias student is likely to be confident in using strong visual images to support their learning. Good readers are often able to visualise incidents from written words, the events in a science experiment or the feel of a key moment in history. Good teachers will try to develop this skill in all readers and they should start with powerful images, helping to engage students with spatial bias profiles.

Think of the famous photograph of the Hindenburg airship as it bursts into flames on arrival in New Jersey in 1937 (see Figure 4). The teacher could start with the photograph or the famous newsreel commentary from Herbert Morrison as he describes the unfolding disaster. This can then be linked to some key facts about the airship, for example, that at the time it was the biggest thing that had ever flown (show its size in comparison with a jumbo jet or an ocean liner) and that it could carry over 100 passengers.

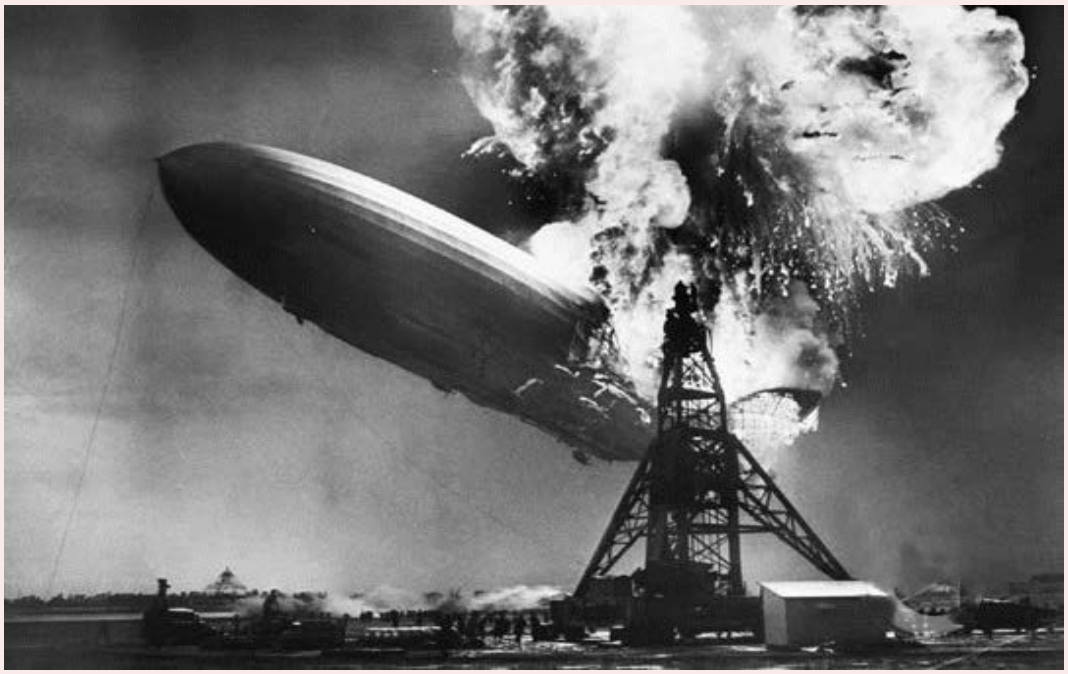


Figure 5 Hindenburg airship crash

This understanding can then be linked to the beginning of a piece of writing – also modelled by the teacher – and in doing so, the essential links between listening and speaking, and then reading and writing have been clearly established.

Accordingly, students could be encouraged to use aspects of drama and role play in their work, for example, the use of tableaux to reveal their understanding about a historical event, a key scene in a play or the way in which a painting is constructed. In a tableau, participants make still images with their bodies to represent a scene. A tableau can be used to quickly establish a scene that involves a large number of characters, and, because there is no movement, it is easier to manage than a whole-group improvisation, yet can easily lead into more extended drama activities. Tableaux can be used to explore a particular moment in a story or drama, or to replicate a photograph or artwork for deeper analysis.

The idea of thought-tracking can be added to the tableau scene that has been created, with student observers questioning characters in the scene created. The participants have to reply in role, explaining their position (literally) and their response to the situation. Extreme spatial bias students like Jenny will also benefit from the opportunity to present their learning in alternative ways that respond to her spatial ability, for example, presenting a history assignment as an annotated multimedia timeline rather than a conventional essay, or writing about the circulation of

blood in the human body through the medium of a labelled flow chart. More generally, such students are likely to appreciate the use of other diagrammatic and visual tools like mind maps and the opportunity to develop web pages in response to an activity. In all such examples, the teacher should be mindful that if the criteria for the completion of any of these activities is made objectively clear, then a student should be able to legitimately respond in a completely different mode and yet still meet those criteria.

Teachers should consider the opportunities for collaboration, critical thinking and the development of self-esteem as a result of extreme spatial bias students' ability to provide a valuable contribution to group work.

Extreme spatial bias students will enjoy active methods of learning, including role play, problem-solving activities and the opportunity to develop original ideas. These approaches fit in well with some of the six facts of understanding as identified by McTighe and Wiggins (2012). The six facets provide a framework that is designed to identify whether students have a deep understanding of the concept being taught. The authors suggest that when a learner truly understands, they can explain, interpret, apply, have perspective, an ability to empathise and have self-knowledge.

It is relatively easy to provide evaluation or assessment criteria for knowledge and skills (two core aspects of learning), but it is much more difficult to do the same for the third – understanding. Expanding on the criteria above reveals a framework that can be used to assess student achievement in evaluating this difficult aspect of learning. Think, for example, of Jenny's likely ability to see 'the big picture' in relation to an aspect of learning – a clear link to the concept of perspective in which students will be able to identify different points of view, understand an idea through another 'lens' and see that big picture. In addition, her spatial skills are likely to support her in the facet of interpretation – a student's ability to tell meaningful stories and provide a historical or personal dimension through images, anecdotes, analogies and models.

Quantitative Reasoning (QR)

Although not part of the *CAT4* profiles as generated by the Individual report, we understand that readers may find it helpful to consider a bias between QR and the other battery SAS results. For this reason, we include here two profiles that are not strictly part of *CAT4* but can be created by teachers experienced in using *CAT4* results.

- **Positive quantitative bias**: Students' SAS in QR are above the other batteries.
- **Negative quantitative bias**: Students' SAS in QR are below the other batteries.

What is quantitative literacy?

We know that students today can access vast amounts of information on the internet. Much of this information is quantitative in nature but, more significantly, has moved from pure research applications to the wider worlds of education, healthcare, media and entertainment, transportation and banking. This is 'big data', and students need to be able to analyse and understand the implications of these applications to their daily lives. All of these situations require good QR skills. QR skills cover more than mathematics. They include the ability to make sense of information displayed in different formats (graphs, tables, diagrams, equations) and the ability to convert information from one format to another.

QR is also about interpretation: using evidence to draw conclusions about data, and the ability to assess the limitations of that evidence. It is the cross-curricular nature of QR together with the developing presentation of information in mixed-media format that has resulted in the concept of 'quantitative literacy'. Whilst students' experience with prose literacy is seen in most subjects through a wide range of reading and writing assignments, the same is not true for quantitative literacy, even though we see its application across curriculum subjects as diverse as history, biology and economics.

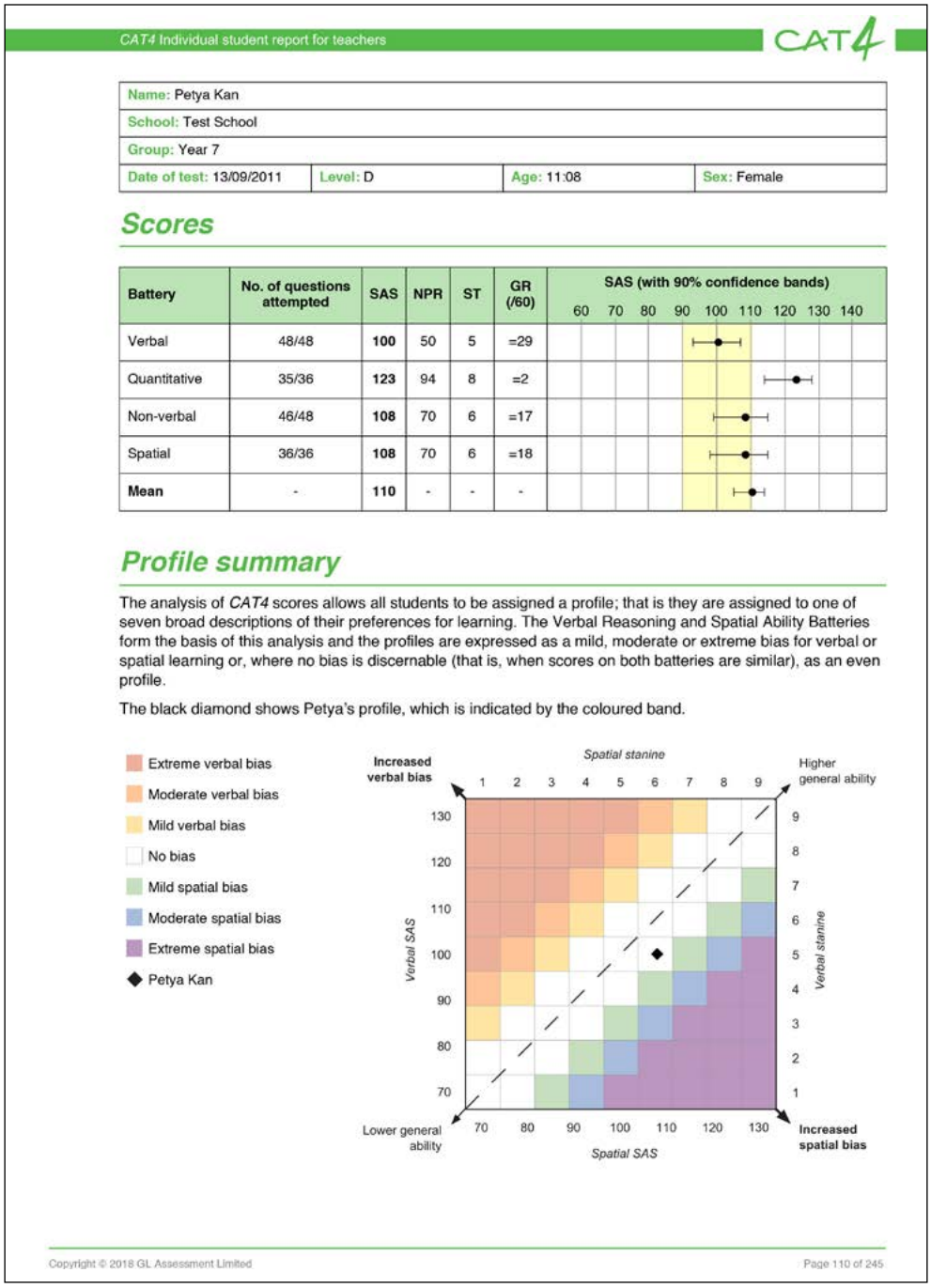
Hughes-Hallett is one of those advocates for the curriculum application of this interdisciplinary nature of QR beyond mathematics and into solving contextual problems in real-world situations. One of the most obvious examples is the global issue of climate change. Larger societal issues like this require the application of QR skills in real-world contexts, whether watching the news headlines on television, reading a detailed newspaper investigation or listening to a politician talking about government policies.

Steen has posited three essential components to applying QR to real-world situations:

1. engagement with the real world;
2. ability to apply quantitative thinking to unfamiliar contexts;
3. adaptable reasoning, or the ability to make judgements even in the "absence of sufficient information or in the face of inconsistent evidence" (Steen 2004).

In a world of 'big data' it is rarely possible to gather all the information necessary to make a solid judgement, and so helping students to draw conclusions in these real-world situations is a key part of any classroom use of QR.

Example of strong quantitative reasoning



CAT4 Individual student report for teachers

Name: Petya Kan			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	Level: D	Age: 11:08	Sex: Female

Scores

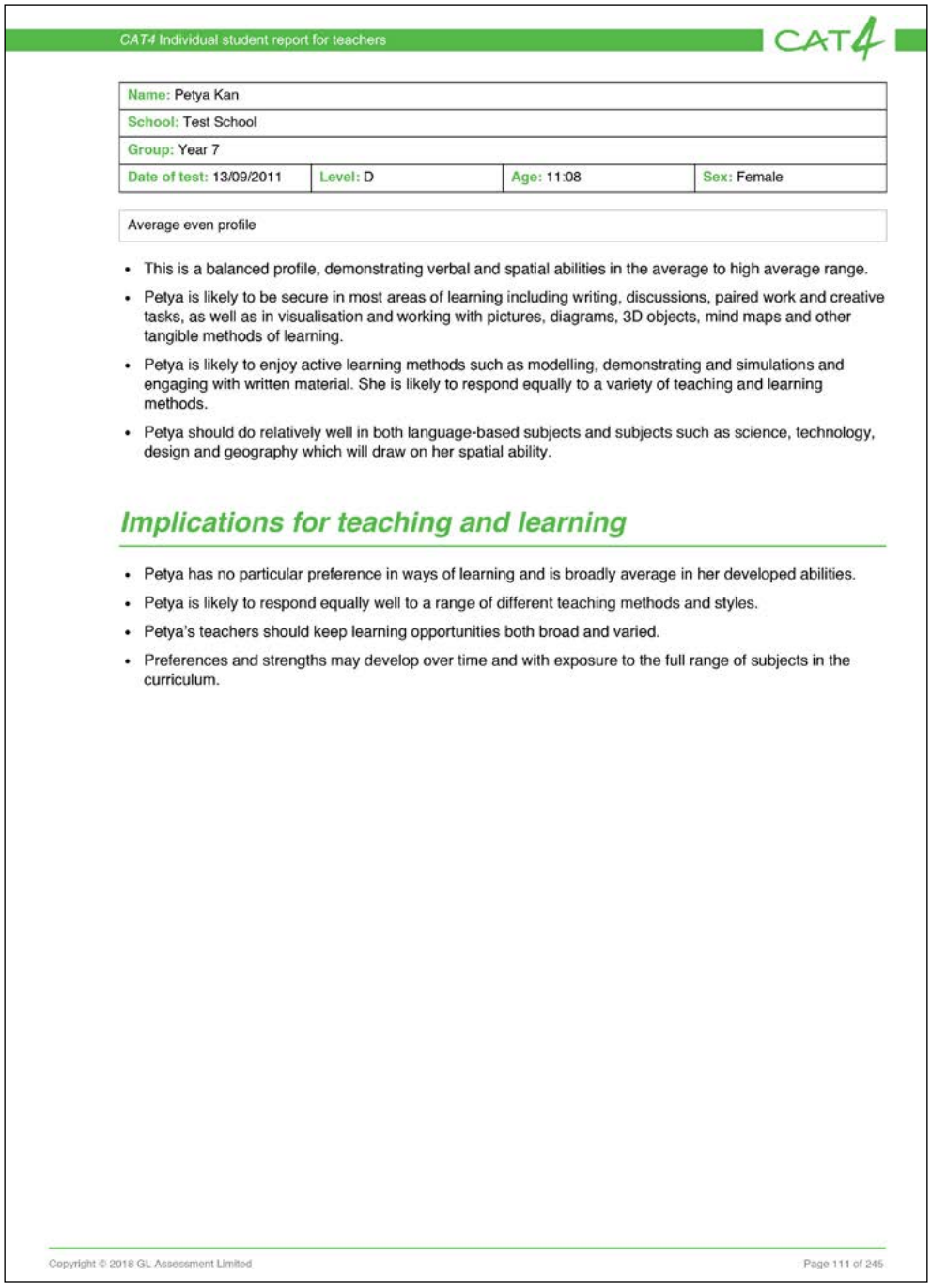
Battery	No. of questions attempted	SAS	NPR	ST	GR (/60)	SAS (with 90% confidence bands) 60 70 80 90 100 110 120 130 140
Verbal	48/48	**100**	50	5	=29	
Quantitative	35/36	**123**	94	8	=2	
Non-verbal	46/48	**108**	70	6	=17	
Spatial	36/36	**108**	70	6	=18	
Mean	-	**110**	-	-	-	

Profile summary

The analysis of *CAT4* scores allows all students to be assigned a profile; that is they are assigned to one of seven broad descriptions of their preferences for learning. The Verbal Reasoning and Spatial Ability Batteries form the basis of this analysis and the profiles are expressed as a mild, moderate or extreme bias for verbal or spatial learning or, where no bias is discernable (that is, when scores on both batteries are similar), as an even profile.

The black diamond shows Petya's profile, which is indicated by the coloured band.

Extreme verbal bias
Moderate verbal bias
Mild verbal bias
No bias
Mild spatial bias
Moderate spatial bias
Extreme spatial bias
Petya Kan



CAT4 Individual student report for teachers

CAT4

Name: Petya Kan			
School: Test School			
Group: Year 7			
Date of test: 13/09/2011	**Level:** D	**Age:** 11:08	**Sex:** Female

Average even profile

- This is a balanced profile, demonstrating verbal and spatial abilities in the average to high average range.
- Petya is likely to be secure in most areas of learning including writing, discussions, paired work and creative tasks, as well as in visualisation and working with pictures, diagrams, 3D objects, mind maps and other tangible methods of learning.
- Petya is likely to enjoy active learning methods such as modelling, demonstrating and simulations and engaging with written material. She is likely to respond equally to a variety of teaching and learning methods.
- Petya should do relatively well in both language-based subjects and subjects such as science, technology, design and geography which will draw on her spatial ability.

Implications for teaching and learning

- Petya has no particular preference in ways of learning and is broadly average in her developed abilities.
- Petya is likely to respond equally well to a range of different teaching methods and styles.
- Petya's teachers should keep learning opportunities both broad and varied.
- Preferences and strengths may develop over time and with exposure to the full range of subjects in the curriculum.

Petya Kan has all her battery scores at or above the national average score of 100. However, she has a particular strength in QR, with a score of 123, significantly above both her verbal (100) and non-verbal (108) scores.

- Students with a strength in QR relative to other batteries are strong in understanding relationships between numbers, in seeing patterns and order in numbers, and in their flexibility in combining and recombining various quantitative elements in meaningful ways.

These profiles tend to be associated with relatively high achievement in mathematics, and in other subjects with a significant quantitative component (such as business studies, science, and statistics), more so than would be expected from their verbal reasoning (VR) scores.

- Conversely, whilst quantitatively biased students may be able to present concise, reasoned arguments using mathematical notation, symbols or diagrams, they may struggle to explain and justify their inferences and deductions verbally.

What does this look like in the classroom?

Effective use of QR in the classroom may be particularly important where students have a positive quantitative bias profile but are less secure in their VR.

Using careful grouping strategies in the classroom (see Alex Honkanen's mild verbal bias profile on page 50), teachers can create scenarios that allow students to share their learning and so help develop better verbal skills in describing data-based information.

EAL students who appear to have a mild, moderate, or extreme spatial bias often actually have suppressed verbal scores which will develop

with the acquisition of the English language. For further help and insight please go to page 77.

If this is the case, then the grammatical strength can be praised and used when asking students to give feedback on each other's writing. Such group work can, in turn, be linked to the development of higher-level writing skills such as using cross-curricular text-type knowledge to structure writing tasks across the curriculum and develop a wider curriculum understanding of the importance of literacy.

Students with a strength in QR may also find an **understanding of computer skills** easier than some of their peers, especially procedures such as using text editors, spreadsheets or cut-and-paste facilities.

Students with high QR scores are typically strong in extracting regularities from their experiences and then reasoning with these abstractions. Their abilities in this area can be developed further through mathematical tasks, games and puzzles. If focused on individual achievement, it is preferable that these games have a non-competitive focus, although in group work a competitive element can bring into focus the valuable asset of the quantitatively strong student with good supporting verbal skills. Teachers can usefully structure groups to take advantage of this.

Examples of strategies for strong quantitative reasoning

The following strategies will be particularly useful in building on the strengths and addressing the weaknesses of students with strong QR.

1. Plenaries and summaries

In addition to a range of different group-work activities, students with this kind of profile across batteries will benefit from a structured approach in one other key area – that of the plenary. The plenary session is an opportunity for students to share their learning, usually at the end of a lesson. The principle is to ensure time for students to share, celebrate and reflect on their learning rather than have it evaluated by the teacher, but the practice is often rather less than this. The issue of timing has always been difficult where the lesson is short – it's not always easy to find enough time to do justice to this principle. Instead, a plenary can be merely a rushed question from the teacher (*OK, what did we learn today – anyone?)* rather than an opportunity for deeper thinking.

It's important that the plenary is given the status it deserves, and so it may not be included in some lessons but could be extended in others. It's the opportunity for the teacher to reflect on whether the objectives of the lesson have been reached and for all students to be drawn towards an evaluation of their learning. The plenary is not designed to be a show or performance. Display elements might feature but this will be incidental: the main point is to enable the teacher and the students to get a sense of the level of achievement across the class. The teacher should be guiding the learning rather than directing it.

Wright has an excellent list of plenary suggestions or challenges in his book *How to be a Brilliant English Teacher* and, like many guides of this kind, they are not subject specific:

- I didn't tell you today's objectives – now, what do you think they were?
- Explain today's learning in one sentence to a specified audience, such as your mum, a seven-year-old child, a class in the year below yours.
- In pairs, what was the most important thing in your opinion that you learned today?
- Sum up today's learning in exactly 15 words.
- In pairs, think up a new (better?) activity to teach today's objective.
- Write an advertisement for a film trailer for today's lesson.
- Write a two-minute radio news story summing up what happened in today's lesson.
- That's the objective, but tell me one other thing you learned today.
- Look back at today's activities – what was the connection?
- Write a newspaper headline for today's lesson.
- Write one more example of your own.
- As a class, complete two columns on the whiteboard headed CLEAR and NOT CLEAR about what we've learned and what still confuses us.
- Write one more thing from today that needs more explanation.

- What would you guess the next lesson will be about, and why?
- What does the next lesson really need to be about?

It's easy to see what this kind of plenary activity is trying to do. Wright is encouraging students to 'speed think': to try to encapsulate their learning, to reconstruct it in a new form that demonstrates real assimilation. Some of the latter plenary suggestions are encouraging students to see 'the big picture' and to contextualise their learning in relation to what has gone before and what is to come. As Wright notes, the learners are "participating in evaluation not so much of their own work or of the teacher's efforts but of the learning as a joint operation".

In addition, this kind of evaluative plenary activity provides an opportunity for teachers to reflect on their own practice in the classroom. Bluntly, did the students 'get it' or not, and to what extent? Time to reflect is just as important for teachers as it is for learners and this structure is one way to start this process.

2. Active retrieval

After a lesson is over it is worth remembering that students will not retain everything they have covered. Long-term memory is an active process just as short-term memory is, as set out earlier on page 10. This advice relates to the six specific practices the use of which is not supported by research evidence, such that re-reading and highlighting is not enough retrieval practice to facilitate future retrieval.

To support this thinking in the classroom and to help learners, teachers can undertake a number of strategies:

- create learning opportunities that help students to retrieve the new learning, for example, quizzes, low-stakes testing and memory games;
- space the retrieval practice activities over time, for example, daily, weekly and monthly;
- test the retrieval of new information in different situations – vary the context and content to help students transfer and assimilate their learning.

Doddle, part of the GL group that deals with informal low-stakes testing through quizzes, has developed a guide called *Making Knowledge Stick: How and Why Retrieval Practice Improves Results* which can be accessed at https://www.doddlelearn.co.uk/retrieval-practice/.

Willingham provides an invaluable list of mnemonic techniques that can be successfully applied in the classroom in his article 'What Will Improve a Student's Memory?' There are also some practical activities for teachers or students that demonstrate the truth of these three principles.

3. Metacognitive skills

Up to now, we have dealt with mainly cognitive skills, for example, preparing students with techniques to approach a set of skills such as reading. One of the most effective skill sets that can be taught at school is for students to know how to know themselves, how to motivate themselves, and explicitly how to improve their own learning processes. Collectively these are known as meta-cognitive 'thinking about thinking', or 'learning how to learn' skills.

When you've reached your goal, take time to ask,
Could I have been better at doing that task?
Take a moment or two to ***think*** *and* ***reflect****,*
Were my ***thinking strategies*** *correct?*
Is there any way to make changes to it,
so that it'll be better next time I do it?
If you want to make your thinking great,
take time to ***reflect – metacogitate****.*

Kite (2000)

This requires time away from the curriculum, and requires students to take greater responsibility for their own learning. However, teaching these skills has been shown to increase progress on the taught curriculum over time. Children as young as eight years old will already have some understanding of their own strengths and weaknesses, and how to regulate their own performance, but these skills can be specifically taught in a school environment.

Modelling from teachers (see page 62) is a very fitting approach for teaching metacognitive skills. The steps that would need to be taught can be as simple as: plan, monitor, evaluate. Ideally these can be tailored to the type of subject matter covered.

1. **Plan:** think about the goal of the task at hand, recall a number of potential techniques that might be relevantly used, filter out the least relevant techniques by process of elimination, and consider how to proceed (maybe selecting the second-best technique for demonstration purposes later).
2. **Monitor:** while carrying out the chosen technique, question whether this is working towards the goal of the task at hand. If not, the technique may be changed for demonstration purposes until the goal is reached.
3. **Evaluate:** actively reflect on how the goal was reached, how the processes were selected and how others might have been better or worse, how to recognise whether the technique is or isn't working, how difficult the task was, and what might be done differently next time.

With other skills being modelled, the worked example should be followed by guided practice and ultimately work towards independent practice, with teachers adding and then removing 'scaffolding' so that students will be able to become independent metacognitive skill users in their own learning in and out of the classroom. To an extent, all modelling implicitly builds metacognitive skills, by allowing the MKO to demonstrate the monitoring that experts do as routine. Teachers can use this consideration to enhance their existing cognitive modelling, but explicitly teaching metacognitive skills will still be advantageous.

Using metacognitive abilities will require the same working memory as the cognitive tasks at hand, and this is one of the key differences between experts and non-experts, as covered at the start of the chapter (see page 103): experts allocate more mental space to monitoring their own performance towards a goal, and find shifting tactics easier as a result. Students with poor reasoning skills are more likely to use trial-and-error approaches to learning, and research has found that low-achieving students are most likely to benefit from explicit tuition in metacognitive skills.

The flip side of this competition for working memory means that developing metacognitive skills is less effective when the material or techniques being selected are unfamiliar, because the attention is taken up by the cognitive rather than metacognitive. This indicates that **metacognitive skills are best modelled with material that is well consolidated**, rather than immediately after learning a technique.

This does not make metacognitive skills superior or more advanced than cognitive skills: returning to the ideas covered around Bloom's Taxonomy, metacognitive and cognitive skills compete for the same mental resources and are mutually beneficial processes to develop. Metacognitive skills cannot be considered without a task set by the cognitive domain.

Example of weak quantitative reasoning

CAT4 Individual student report for teachers

Name: Aelwyn Probert			
School: Test Welsh School			
Group: Class 7A			
Date of test: 02/09/2013	**Level:** D	**Age:** 11:07	**Sex:** Female

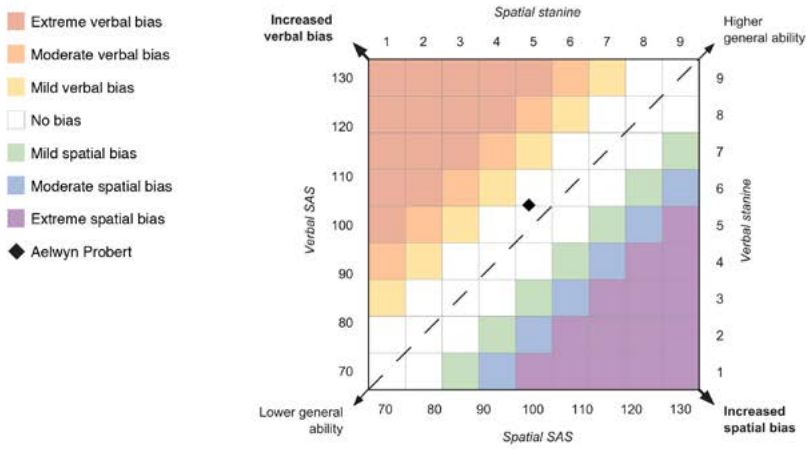
Scores

Battery	No. of questions attempted	SAS	NPR	ST	GR (/30)	SAS (with 90% confidence bands) 60 70 80 90 100 110 120 130 140
Verbal	48/48	**104**	60	6	=17	
Quantitative	23/36	**85**	16	3	25	
Non-verbal	28/48	**97**	42	5	=16	
Spatial	24/36	**99**	48	5	21	
Mean	-	**96**	-	-	-	

Profile summary

The analysis of *CAT4* scores allows all students to be assigned a profile; that is they are assigned to one of seven broad descriptions of their preferences for learning. The Verbal Reasoning and Spatial Ability Batteries form the basis of this analysis and the profiles are expressed as a mild, moderate or extreme bias for verbal or spatial learning or, where no bias is discernable (that is, when scores on both batteries are similar), as an even profile.

The black diamond shows Aelwyn's profile, which is indicated by the coloured band.



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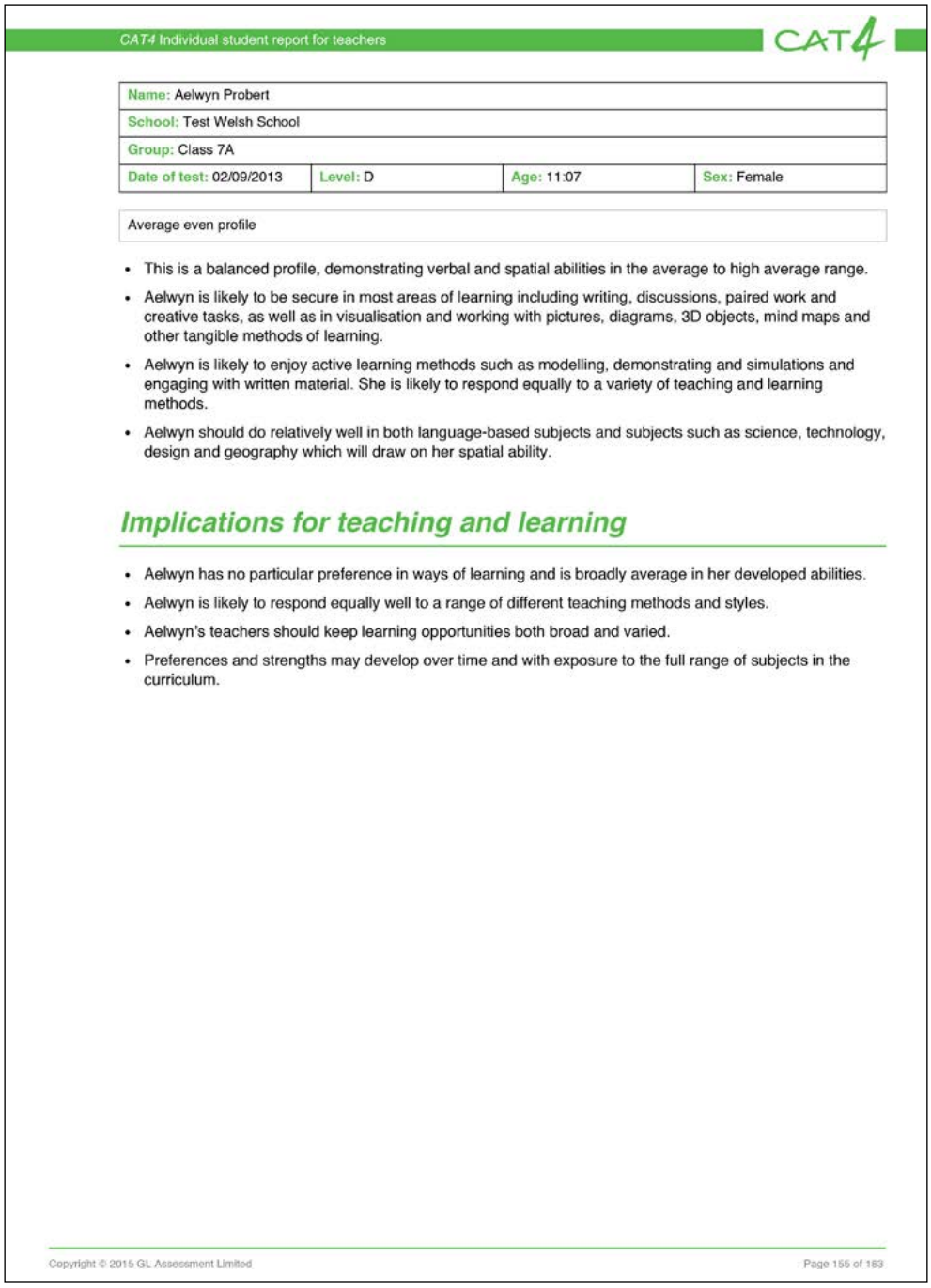


CAT4 Individual student report for teachers

CAT4

Name: Aelwyn Probert			
School: Test Welsh School			
Group: Class 7A			
Date of test: 02/09/2013	**Level:** D	**Age:** 11:07	**Sex:** Female

Average even profile

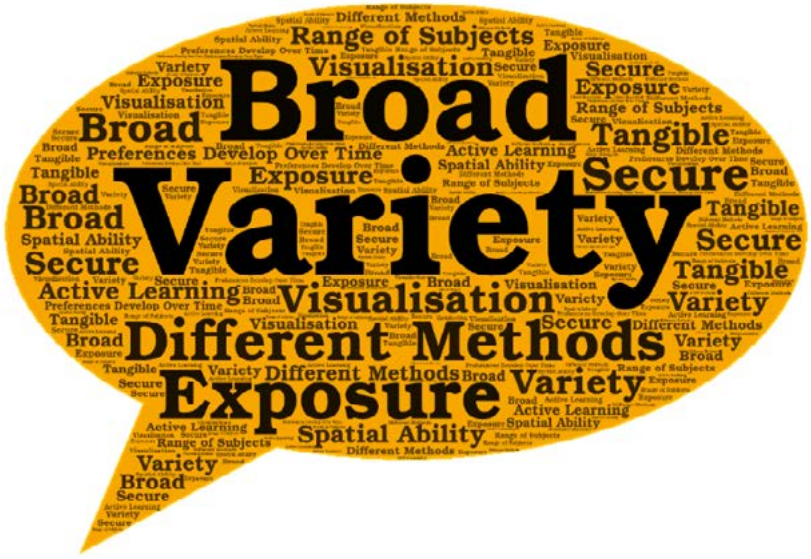
- This is a balanced profile, demonstrating verbal and spatial abilities in the average to high average range.
- Aelwyn is likely to be secure in most areas of learning including writing, discussions, paired work and creative tasks, as well as in visualisation and working with pictures, diagrams, 3D objects, mind maps and other tangible methods of learning.
- Aelwyn is likely to enjoy active learning methods such as modelling, demonstrating and simulations and engaging with written material. She is likely to respond equally to a variety of teaching and learning methods.
- Aelwyn should do relatively well in both language-based subjects and subjects such as science, technology, design and geography which will draw on her spatial ability.

Implications for teaching and learning

- Aelwyn has no particular preference in ways of learning and is broadly average in her developed abilities.
- Aelwyn is likely to respond equally well to a range of different teaching methods and styles.
- Aelwyn's teachers should keep learning opportunities both broad and varied.
- Preferences and strengths may develop over time and with exposure to the full range of subjects in the curriculum.

- These are students who are relatively weak in understanding relationships between numbers, in seeing patterns and order in numbers, and in their flexibility in combining and recombining quantitative elements in meaningful ways.
- If the absolute quantitative score is very low (stanines 1-3), and if in class work the student's difficulties appear to be confined to numbers, then it is possible that a specific arithmetical difficulty (or dyscalculia) is involved.

Aelwyn Probert has verbal and non-verbal scores that are at or above the national average, but her quantitative score is 85, placing her in stanine 3 and below average.



What does this look like in the classroom?

As noted previously, if a student's quantitative score is very low in relation to other scores then this can indicate some specific arithmetical difficulty or dyscalculia, or mathematical anxiety.

- Research has suggested that dyscalculic students may have problems understanding that number words and numerals refer to the size (or numerosity) of the sets they denote.
- Such students may not understand that collections of things have a numerosity and that manipulations (for example, combining collections or taking sub-collections away) affect this.
- Additionally, these students may also not understand that collections need not be of visible things – they can equally be audible things, tactile things or abstract things (like wishes). These indications may alert the teacher to the need for a more detailed investigation of the student's capabilities and, as with dyslexia, an appropriate test will be beneficial.

GL Assessment provides a Dyscalculia Screener, an assessment tool which identifies dyscalculic tendencies in learners aged 6–14+ years. It provides recommendations for intervention strategies that will support students and help them to achieve their potential. This 30-minute test can be delivered to a whole class or to individual students and will play an important role in helping both specialist and non-specialist teachers distinguish between those individuals who have poor maths attainment and those whose difficulties are associated with dyscalculia.

Separately, the *Dyscalculia Guidance* will tailor the general advice to students who have specific problems with numerosity. Like the *Dyslexia Guidance*, it contains resources that are useful for students with or without a formally recognised diagnosis.

Dyscalculics do not have reduced working-memory span for words, unlike dyslexics. Problems with numerosity will be expected to impact *CAT4*'s Number Series, while those students with poor working-memory span for words might also be expected to do worse at QR, as with other batteries. There is some evidence that developmental dyscalculia is related to problems with working memory for visuo-spatial material (Szucs et al., 2013), so it is possible that these students will also exhibit lower scores in spatial ability. *CAT4* is not designed to be indicative of dyscalculia, and has not been validated as such, so these areas are merely suggestions for consideration.

Readers will notice here that it has been recognised that working memory might be split down the lines of verbal/spatial rather than being monolithic, as in the introduction to memory earlier in the chapter (see page 10). This was not introduced earlier for the sake of simplifying the explanation of working and long-term memory, but cognitive psychology indeed suggests that there are distinct aspects of working memory (Baddeley and Hitch, 1974) and offers refinements to the simpler Atkinson and Shiffrin (1968) model by positing separate sub-systems, called the 'visuospatial sketchpad' and 'phonological loop', to accommodate evidence of dissociations observed between young people's working-memory abilities. Ultimately, these dissociations are mirrored in the *CAT4* profiles by contrasting spatial ability with verbal reasoning, which, although correlated to a high degree, can show important divergences.

Examples of strategies for weak quantitative reasoning

Strategies for supporting weak quantitative reasoning learners include activities to support and improve working memory.

1. Reduce burden on working memory

One way to improve the learning experience for students with weak quantitative reasoning or a below average no bias is to reduce the number of things that must be held simultaneously in working memory. As identified in the guidance for Bisset Billy (see page 31), some students will have difficulty coordinating what they hear with what they see, or what is on the board with what is on the paper in front of them. Eliminating the need to remember ideas, even temporarily, can greatly assist these students. Working-memory burdens can also be reduced by relating new material to familiar concepts, for example, using a 12-inch ruler as a physical analogy to illustrate the measurement of mental qualities such as attitude scales or market research.

This can also work at a more complex level by making concrete analogies to familiar physical systems, for example, thermostats; mechanical systems such as levers, balances and scales; hydraulic systems such as drip feeds and overflows. Finally, 'overlearning' (and therefore making automatic) basic processes such as writing or number facts will free up the student to spend greater time on the more demanding aspects of the learning activity or task.

All learners (including teachers) gain more when they are actively involved in the learning process. Developing and then sustaining engagement is a powerful motivation, and teachers should start by ensuring that the learning environment they create encourages active involvement.

2. The physical environment

Firstly, teachers should ensure that their classrooms look like the kind of place where learning is happening. It may be valuable to think about what the room feels like for students – so ask them! As Dillon notes:

> *I haven't been in a classroom in the country that couldn't remove 10 or 15 things ... Every time a human being comes into a space, they visually process the entire room*

> *… by the time we actually ask [students] to intellectually engage, they're visually exhausted.*
>
> Dillon (2018)

There is an increasing amount of research that has endorsed the value of creating a physical learning environment that offers students choices and is characterised by an uncluttered, harmonious environment. This relates to the ideas of working memory again, such that the more focused the working memory on the task at hand, the better the retention will be.

Some teachers have redesigned their classrooms to look more like a contemporary coffee shop than a traditional classroom, as Delzer noted in a 2016 Edutopia blogpost:

> *I was working on my TEDx presentation at my local Starbucks and, looking around, I realized that everyone seemed to be happy, engaged in their work, and relaxed. Some people chose the traditional chairs and tables while I opted for a big, comfy chair with my MacBook on my lap. The quiet music, perfect lighting, and overall aesthetics of the coffee shop were favourable for a variety of learners. And if I wanted to switch up my seat during my stay, I was free to do just that. That's when I decided that our classroom … was going to look radically different than anything I'd ever done before.*
>
> Delzer (2016)

Although working-memory span is not readily changed with practice, reducing the 'noise' that might reach the mind and compete for mental resources with the 'signal' that a teacher wants a student to receive and think about, might effectively allow better cognition and metacognition.

3. Maths anxiety

CAT4 deals with quantitative reasoning that requires only basic levels of arithmetic skills, and this is deliberate to reduce the amount of prior education a student requires to access the demands of the items. However, one of the potential causes of particularly low quantitative reasoning scores relative to other batteries may be due to a modern phenomenon labelled 'maths anxiety': the emotional disturbance that some students feel when presented with challenges that look mathematical.

A new report, *Building a numerate nation: confidence, belief and skills* by National Numeracy and TP ICAP (2019), reveals that millions of adults still lack basic numeracy skills, leaving them unprepared for the workplace and everyday life. The report confirmed that there has been no progress in meeting targets set 20 years ago by the then UK government.

Brain-imaging studies have found that people with maths anxiety will experience activation in parts of the brain to do with threat detection and pain when they think about doing upcoming maths problems. For these students, maths *hurts*, and they will want to avoid anything to do with it. Students with maths anxiety experience less activation in areas associated with working memory and reasoning when working through problems. Worrying about maths will divert mental resources away from the task at hand, thereby decreasing the working memory that can be allocated to proper cognition and metacognition.

This may be related to the perception of maths being gendered. Mean SAS in QR are 1.5 points higher for boys than girls, despite the content having nothing inherently 'masculine' or 'feminine' about it. Adults can have stereotypes about children's maths performance, such that they might expect a daughter to struggle more with maths than a son. Again, this might act as a self-fulfilling prophecy, since when females are made aware of such expectations their performance decreases. Gender differences in maths anxiety are more pronounced in secondary education than primary education, and more pronounced in adults than in secondary education, suggesting that girls are more likely to spiral faster than boys.

Cognitive psychology disagrees with this acquired and minority view. Evidence suggests that maths skills are like any other, and that targeted practice can and will improve such capabilities. There is no genetic coding for innate maths ability, and teachers who address this view might go some way to reducing students' anxiety towards maths. Some evidence even suggests that teachers with low self-confidence that do not model mathematical reasoning properly can cause maths anxiety in their students by inadvertently suggesting that there is only right and wrong, so no pressure!

Instead, teachers should aim to encourage students to think about maths as a series of finding solutions to problems, and that the journey counts as much as the destination. Arguably, this is why

maths more than any other subject asks students to 'show their working'. Modelling these thought processes will show that experts apply a set of steps to approach new problems, and that these steps can be understandable and relatable to existing knowledge.

> *At the start of the different projects the teachers would introduce students to a problem or a theme that the students explored, using their own ideas and the mathematical methods that they were learning … Sometimes teachers taught the students mathematical content that could be useful to them before they started a new project. More typically though, the teachers would introduce methods to individuals or small groups when they encountered a need for them.*
>
> Boaler (2015)

Teachers can explore these approaches further in Jo Boaler's website (https://www.youcubed.org).

Understanding that students who suffer from maths anxiety might not have the same breadth or depth of learning from previous experience will also help establish the best starting point to rebuild any lost confidence or progress. This is a key issue to which we have returned throughout this chapter - small steps are effective when teachers start from the right place.

Conclusions: Enabling students to take ownership of learning

CAT4 data comes with an obligation on the part of the teacher. Data is meaningless unless it can be applied and, in this case, applied to student learning so that they are challenged and supported as they make further progress, guided by effective teacher strategies. As teachers begin to take ownership of the data, becoming more confident in its application, some of that ownership can be passed to the students themselves. As we have seen in this document, for students to take ownership of their learning, they need to know what outcomes the teacher wants, in language that means something to them and using examples that are clearly understood.

Teachers' understanding of what their students know is important for making successful teaching steps that start from the right place. *CAT4* cannot help with this, since each student's specific level of skills is best discovered with experience and unstandardised questions and answers. Building on an understanding of a student's interests, skills,

weaknesses, motivations and anxieties is the best way of grounding lessons, but even then, young people will continue to surprise a teacher.

Scaffolding and modelling support skill acquisition by demonstrating the steps in a process that an expert would apply to a new problem. When skills become 'overlearned', and, thus, automatic, metacognitive processes can be taught explicitly to close the gap between a set of learners and experts. The ideas of active retrieval to minimise forgetting, plenaries to summarise, and contextualising new information in relation to previous information will help 'raise the tide to raise the boats' for the majority of the class.

Group work that is structured to get the best from peer-learning and modelling, paying particular attention to the demands of verbalisation, will support active learning, adding an invaluable tool to the teacher's repertoire. Being confident with using visual media, mnemonics, games and such will provide a range of learning angles that can enhance later recall of material.

Understanding that students may have specific learning difficulties that might get in the way of realising their expected potential is a key skill for teachers also. These barriers could include low levels of English language fluency, dyslexia, dyscalculia, low self-esteem or negative attitudes to one's own learning capacity. Although often not flagged by *CAT4* directly, this document has introduced these concepts as angles for consideration by the teacher who receives a pattern of results that they are not expecting from a student.

A teacher's job is not easy. Managing groups of people through their learning journey into adulthood and successfully balancing their cognitive, metacognitive and non-cognitive development is something that GL can only hope to assist with indirectly through insight and consideration of research and best practice. We hope that teachers around the world continue to find these insights relevant and helpful to them and, ultimately, to their students.

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Neil MacRae

Neil MacRae is a PGCE course director, published freelance writer, English and Drama adviser, university lecturer, public speaker and classroom teacher. He is now a freelance educational consultant and founder of Personal Best Learning, a company created to support international education projects. Neil delivers bespoke training around the world: in 2017 he travelled to the Sudan, Tanzania, China, Indonesia, India, Malaysia, Mongolia and Cambodia to work with teachers and senior leaders in a wide range of training environments. Neil is now based in Singapore.

He continues to provide long-term ongoing curriculum development and classroom management advice for school groups in India, China and Indonesia. Neil is also an approved trainer for two leading education providers – Fieldwork Education, creator of three very successful international curriculums, and GL Assessment, provider of one of the world's leading formative assessment programmes.

Neil firmly believes that the most successful teaching strategies can work for teachers of all subjects and ages of students.