A Short Good Practice Guide | **April 2017**

Supporting Students in STEM with Colour Vision Deficiency

IOP Institute of Physics

This is a guide on good practice in supporting STEM students who have colour vision deficiency (CVD) or, as it is commonly known, colour blindness. The aim is to provide you with knowledge and understanding of adjustments and support for STEM students with CVD.

There is a general assumption that everyone can see colours normally and many modern teaching methods rely heavily on the use of colour to teach, highlight and explain. Most resources and educational tools, especially software (such as coding software), rely on this ability to see colours.

- But what if the colours being described are not the same for all students?
- What if colour contrasts are not so apparent to some students?

CVD is not a life-threatening condition and won't hold anyone back if they are diagnosed early and offered appropriate support. It does, however, require sensitive understanding from teachers, lecturers, educators and peers.

Many students with CVD are not aware that they have the condition as it's something they've been born with, lived with and worked around all their life. People with CVD become very adept at distinguishing between subtle differences in shade or hue, and the older a person becomes, the more time they will have had to hone their coping techniques. However, this does not mean that they don't make mistakes because sometimes their coping techniques won't work. If they are repeatedly exposed to situations in which they are expected to interpret colour accurately, even if they are diagnosed, their confidence in their own abilities may drop.

Without adequate understanding and support, CVD can be a major disadvantage in many STEM subjects where the use and understanding of colour is essential for some aspects. Good CVD intervention is about understanding that not everyone comprehends and sees colour in the same way and adjusting practice accordingly.

"The use of colour is ubiquitous in the world today, in advertising, web design, desktop and mobile displays, fashion, product packaging, signs and signalling, data visualisation, graphics, uniforms and costumes, and many more human activities and jobs, as well as, most importantly, in education and training. Nowhere is the problem worse than for colour-blind children who fail to learn or achieve because they see colours differently, and whose teachers and schoolmates often do not recognise their colour vision deficiency. This guide seeks to explain what colour vision deficiency is, how it might be recognised, and what the key steps are that must be taken to improve practice so that students with colour vision deficiencies are able to progress normally."

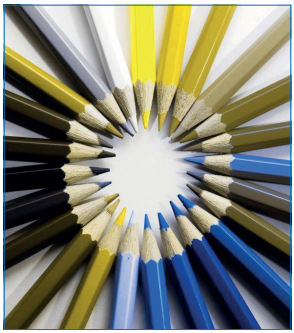
Dr Lisa Shaw
Senior Lecturer in Pharmacology
University of Central Lancashire

Understanding CVD

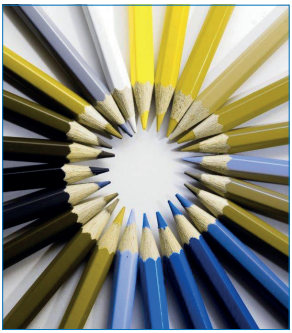
As CVD is linked to the X chromosome, it is much more likely to affect males. It is estimated that one in 12 (8%) of all males and one in 200 females have some degree of colour vision deficiency. Statistically, this means that there will be at least one student with CVD in every average, co-ed science class of 30 students in a school, and more in a first-year STEM lecture.

Everyone's visual experience depends of the absorption of light by the three main types of cone in the retina (red, green and blue) and the balance between them. Those with CVD have deficiencies in these cones, with the most common forms being protanomaly (red-cone deficient) or deuteranomaly (green-cone deficient). Tritanomaly is a rare form of blue-cone deficiency and monochromacy is an extremely rare form with only greyscale vision.

Normal vision



Protanopia



Deuteranopia

In the most severe 25% of cases of red/green deficiencies (protanopia and deuteranopia) one cone type is absent – this condition is known as dichromacy.

In all cases, however mild or severe, accurate perception of more than just one colour is affected. People can have problems with colours right across the spectrum, particularly reds, greens, oranges, browns and greys, but blues and purples are often confused.

Children are no longer routinely screened meaning many are unaware that they have some form of CVD. While colour-blind children can learn to identify some colours through their hue and saturation – and experience – they cannot actually see all of them and this could affect their performance and understanding in many STEM subjects. They may be slower to follow instructions because those relating to colour may make little sense. Indeed, they may seem slow or hesitant in many situations as they'll be perplexed by the need to make choices based on colours that they simply cannot see.

When colour-blind students are faced with a variety of options based solely on colour, they will not only struggle to distinguish between them, but they will probably make errors that will compromise their work. When they're taught using colour alone, they'll spend their time trying to work out what is being explained or highlighted and fail to absorb the information efficiently or correctly. Every day in STEM, people with CVD are trying to negotiate diagrams, graphs, pie charts and prisms, or even using spectroscopy or identifying resistors.

> *"Being colour-blind myself, I am increasingly aware of how much students with CVD are actually missing in our classrooms. Through teaching, I have discovered what had been hidden from my sight; I hadn't known what colours were meant to be visible when studying at school and at university! Schools increasingly use colour in the classroom and many undiagnosed students with CVD of course don't know what they can't see. When students know that they are likely to be missing something, they can ask for extra support from their peers or from the teacher. Diagnosis can be empowering."*
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> **Dr B King**
> Teacher of STEM and geography

Supporting students with CVD

Do:

- Be aware of CVD and how it may present
  - Remember that you may also be working with other staff who also have CVD
- Audit the learning environment for the use of teaching or lab work that solely uses colour
  - This should include computer-based interactive whiteboard/homework software packages and resources to ensure important information is not conveyed in colour alone
  - Make use of apps to see your own classroom and resources as your colour-blind students might, so that you can easily make adjustments
- Teach using natural light where possible
  - Bright, low, inside or natural light can affect colour recognition and better the natural light the easier it is to recognise colour. Ensure that the lab environment is well lit, for example
- Use strong colour contrast – you can check if contrast will be visible by photocopying resources into greyscale
  - When using a whiteboard, a visualiser or computer screens use, strong contrast to display information as projectors tend to "wash" colour out
  - If you need a colour other than black, blue is the best contrast to use against white as people with CVD can generally distinguish blue
- Use secondary indicators alongside the colour by underlining or circling the words you wish to emphasise or use a different font. This will avoid singling out individual people
  - For example, when teaching the colour spectrum, use labelling such as ROYGBIV on diagrams
- Use clear lines and boundaries between colours
- Assign a colour buddy to help a known CVD student where coloured diagrams or pictures are being used, especially in experiments and coding
  - Work with the student one-on-one for a few minutes to ensure that they can understand the information in another way
- Use large objects held apart for demonstrations
- Ensure students are given proper access arrangements for exams in schools
- When setting exams, consider the use of colour in papers and use secondary labelling
- Teach all students about CVD to ensure that everyone understands good colour practice and the issues around CVD

Try to avoid:

- Using red, green or pastel shades to highlight your teaching points
- Using coloured pens to mark work, other than blue
- Using colour only to highlight different teaching points – use secondary labelling (numbers, patterns, etc)
- Worksheets/software/maps/charts that rely on colour alone

Don't forget to make use of technology that can assist your CVD pupils such as the colour accessibility functions in iOS 10, Google Chrome extension for colour accessibility. Some apps can name colours while others convert hues to more easily distinguishable colours. Try to remember these tools may assist but they don't offer a complete solution for students with CVD.

References and further reading

- Colour Vision Deficiency and STEM teaching
  Louise Maule and David Featonby 2016 *Phys. Educ.* **51** 035005
- Featonby D Science in School issue 35 24/02/2016: Fifty shades of Muddy Green
  scienceinschool.org/content/fifty-shades-muddy-green
- ColorAdd, **coloradd.net**
- Colour Vision Testing: what can be achieved in everyday practice?
  Holmes W (2011) *Optometry in practice* **12(4)** 167–178
- Colour Blindness Nature Methods
  Wong B (2011) 441 doi 10.1038/nmeth.1618
- The Colour Blind Awareness organisation, **colourblindawareness.org**, has an excellent website giving details and practical advice. Colour Blind Awareness advises NOT to use a colour chart as these are confusing to CVD students and don't always assist
- For more information about access arrangements for external exams in schools for those with CVD, visit **jcq.org.uk/exams-office/access-arrangements-and-special-consideration/regulations-and-guidance**

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We would sincerely like to thank David Featonby (Science on Stage Europe), Kathryn Albany-Ward and Marie DiFolco (Colour Blind Awareness) for their help and support in writing this booklet.

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Institute of Physics
76 Portland Place, London W1B 1NT
Tel +44 (0)20 7470 4800
Fax +44 (0)20 7470 4848
www.iop.org

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