MAYOR OF LONDON

Breaking the Gender Barriers in Computing

Monday 12th, October 2020

TECHUCATION

@ShorifaKhanam

HELLO!

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Today's session

Explore a range of strategies that can be embedded into your classroom to increase more female participation in computing.

GUESS WHO? ♂

https://commons.wikimedia.org/wiki/File:Bill_Gates_July_2014.jpg

https://commons.wikimedia.org/wiki/File:Steve_Jobs_Headshot_2010-CROP2.jpg

https://commons.wikimedia.org/wiki/File:Mark_Zuckerberg_F8_2018_Keynote_(cropped_2).jpg

https://commons.wikimedia.org/wiki/File:Mark_Zuckerberg_F8_2018_Keynote_(cropped_2).jpg

GUESS WHO? ⚥

Adele Goldberg
Only women amongst men built Smalltalk 80 programming Language and GUI. Steve Jobs admitted Goldberg helped him develop the future of computing and Apple after she was forced to show him the technology..

Grace Hopper
Developed the first accessible computer programming languages written in English.

Dorothy Vaughan
American mathematician and computer programmer who made important contributions to the early years of the U.S. space program and who was the first African American manager at the National Advisory Committee for Aeronautics (NACA),

Ada Lovelace
Ada is considered the first computer programmer.

UNCONSCIOUS BIAS

Unconscious bias is when:

We make judgments or decisions on the basis of our prior experience, our own personal deep-seated thought patterns, assumptions or interpretations, and we are not aware that we are doing it.

https://royalsociety.org/~/media/policy/publications/2015/unconscious-bias-briefing-2015.pdf

Exposure to 'Unconscious Bias' can trigger self-fulfilling prophecies by changing stereotyped groups' behaviours to conform to stereotypes, even when the stereotype was initially untrue

Raising Awareness of UB

It's important to ask yourself, what signals are you sending? In your body language, in your casual comments and feedback?

- Are you aiming whole class discussion at a particular group of students?
- Do you use exclusive language e.g. "OK guys!"
- Competition vs collaboration – is there a mixture within your classroom?
- Have you provided a diverse range of role models on classroom displays?
- Do you set tasks which have barriers for some students (e.g. internet access)?
- Are your activity contexts excluding or disengaging certain groups?

One of the best ways to find out is to record yourself in a lesson and watch it back.

https://community.computingatschool.org.uk/resources/61/single

The challenge

23% increase in entries for A Level Computer Science for female students when compared to last year

GCSE Computer Science results in 2019, what percentage of girls took CS?

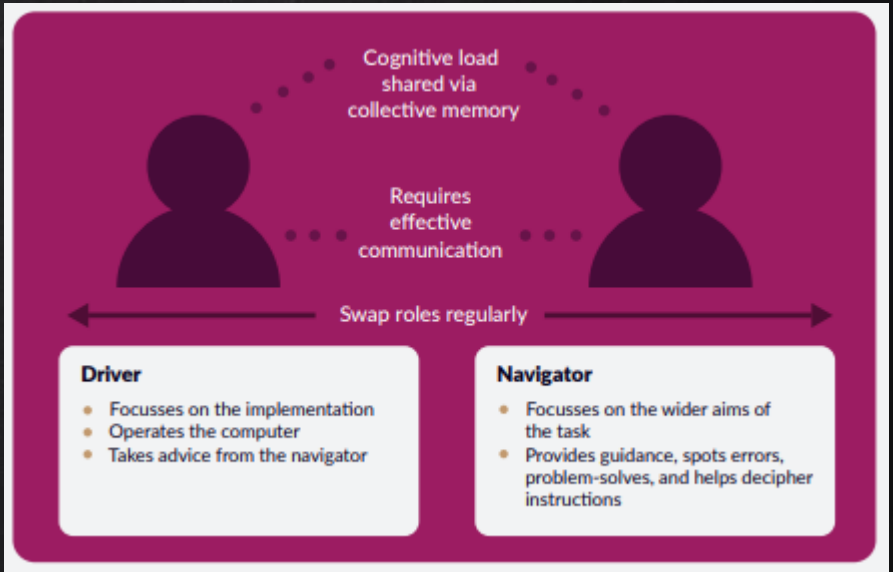
A level Computer Science 2019 results, what percentage of girls took CS?


Strategies

Paired Programming

'Although pairing helps all students, we believe that it is particularly beneficial for women because it addresses several significant factors that limit women's participation in computer science.'

Werner, L., Hanks, B. & McDowell, C. (2004) Pair-programming helps female computer science students



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Paired Programming

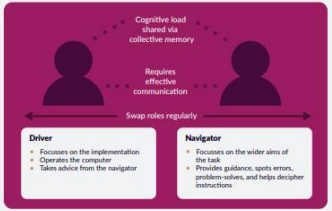
National Centre for Computing Education

Raspberry Pi

Pedagogy Quick Reads

Pair programming supports learners to produce better solutions to complex programming problems

Pair programming is a pedagogical approach that you can use in your classroom which involves learners working together on a problem to develop programs. This Quick Read aims to highlight the benefits of the approach, as well as factors to consider when applying pair programming in the classroom.



What is pair programming?

Pair programming is an approach where two people work together to write a program or solve a problem whilst sharing a single computer. Pair programming is routinely used in the software industry and soon came to education as the observed benefits became clear.

Application of this concept is more structured than simply asking two learners to work together. Pairing learners without giving guidance as to how you want them to work together can often lead to one, or both, learners quickly losing focus. There needs to be an initial investment of time to develop effective paired work. Ideally, both learners should be **engaged and contributing equally** to the task. Poor communication can be detrimental to the pair's collaboration and can cancel out the benefits of pair programming. Therefore, an essential part of making pair programming a success is spending time ensuring that learners have a good understanding of the roles that they will fulfil during the task.

The **driver** will control the keyboard, mouse, or pen, depending on the task. They will type the code or write out the algorithm as instructed by the navigator. These tasks have a low-level cognitive demand for the learner and allow them to concentrate on writing code accurately, rather than also having to focus on tasks such as problem-solving, deciphering the instructions, and algorithm development.

The **navigator** will support the driver, watching with a keen eye for any errors being made. The navigator will also play a strategic role by thinking of alternative solutions to problems, reading the notes from the teacher, or even walking around the class to look at what others are doing. These tasks have a higher cognitive demand than the tasks of the driver, but as the navigator doesn't have the responsibility of having to write the code, the extraneous load on each member of the pair is reduced.

Learners choose, or are assigned, an initial role and once the task has started, they **swap roles regularly** – approximately every 5 to 10 minutes (depending on the activity). This will make sure that everyone is playing an equal and active role, and they are encouraged to think in different ways and both take ownership of the problem that they are solving.

Summary

Driver/navigator

- Learners take turns playing the role of the driver and the navigator, swapping roles at regular intervals
- The **driver** controls the keyboard and mouse and will write the code
- The **navigator** focusses on the wider aims of the task, spots errors, problem-solves, and reads out instructions to the driver

Benefits

- Reduction in individual **cognitive load** via the collective working memory effect
- Improved confidence in finding solutions, particularly among female students
- Improved quality of programs (fewer errors, more efficient and elegant code)
- Retention of learners' interest in the activities, lessons, and subject

Key considerations

- Communication is key: spend time modelling, emphasising, and rewarding these skills
- Spend time ahead of the lesson carefully planning the pairings based on skills, personalities, or friendships
- Ensure that both the driver and navigator are always working on the same task at the same time
- Experiment with length of intervals to suit your learners' needs
- Ensure that summative assessment is based on paired and individual work/tests, with a greater weighting to individual work
- Check that both members of the pair are fulfilling their roles, and do not allow one to dominate

Suggested benefits

There are several benefits from pair programming that have been observed through a range of studies. For example, through pair programming, the learners' **individual cognitive load is reduced**, because the tasks to complete are shared between them. This is known as the **collective working memory effect**. Pair programming "separates tasks with low-level demands (typing, computer management and navigation) from tasks with higher cognitive demands (syntax analysis, algorithm development, problem search)".[1] However, poor communication between learners can create additional cognitive load, which could eliminate the benefits of this effect (see 'Pairing learners').

Another benefit of pair programming is the likely **improvement of the quality** of the programs produced by the learners. The learners support each other by debugging, spotting syntax errors as they occur, and making their code more elegant and efficient.

Although most studies conducted so far have been with university students, they suggest[2] that pair programming has its biggest impact with learners with less advanced skills and lower confidence, or with groups of learners studying introductory courses in programming.

Although research shows that pair programming benefits all learners, there is some evidence that suggests that the technique has a **greater impact on girls**. In studies conducted on learners taking foundation programming courses in higher education, Werner et al.[3] reported a significant increase in confidence levels reported by the women who were paired, compared with the women who worked independently. Similar findings by Braught et al.[4] showed that women who worked alone were more frustrated than women who worked in pairs.

Whilst evidence shows that pair programming can benefit girls in terms of results and their perception of the subject, there is **no evidence to suggest that it has a negative impact on boys**. Hanks found that female students have more positive impressions of pair programming than their male counterparts, but the differences were not statistically significant.[2] Allowing female learners to work together might help maximise some of the benefits of this approach.

Practical considerations

Pairing learners

As an educator, you will need to use your professional judgement to choose the best pairings in order to optimise the benefits of the collective working memory effect.[1] Key factors that could be considered when creating pairs include the following:

- The learners' **personalities and social affinity** (degree of comfort working together) should be considered for sustained or complex tasks, as the pair will benefit from their established relationship.[5]
- Many studies advocate focussing on the '**skill sets**' of the learners when pairing. Whilst there is no consensus from research as to which skill-based pairings are most successful, it is good to start by pairing learners with more advanced skills with learners with less advanced skills.

Whichever method of pairing you opt for, it is important to check in regularly with pairs to ensure that they are working well.

Assessment

Learners should be assessed on **both their paired work and their individual work**. It is not recommended that any summative assessment be based solely on the work that they complete as a pair. Preston[5] makes two recommendations for assessment to encourage **individual accountability** with pair programming:

- Assessment should require students to develop code, interpret code, or both
- Assessment scores for individuals should be weighted more heavily than the joint project score when determining the final grade

Further advice and guidance can be found in a middle school–focused paper by Werner and Denning.[6]

References

1. Sands, P. (2019) Addressing cognitive load in the computer science classroom. *ACM Inroads*, 10 (1), 44–51. Available from: doi.org/10.1145/3210577.
2. Hanks, B., Fitzgerald, S., McCauley, R., Murphy, L. & Zander, C. (2011) Pair programming in education: a literature review. *Computer Science Education*, 21 (2), 135–173.
3. Werner, L., Hanks, B. & McDowell, C. (2004) Pair-programming helps female computer science students. *ACM Journal of Educational Resources in Computing*, 4 (1). Available from: doi.org/10.1145/1060071.1060075.
4. Braught, G., Wahls, T. & Eby, L.M. (2011) The case for pair programming in the computer science classroom. *ACM Transactions on Computing Education*, 11 (2). Available from: doi.org/10.1145/1921607.1921609.
5. Preston, D. (2005) Pair programming as a model of collaborative learning: a review of the research. *Journal of Computing Sciences in Colleges*, 20 (4), 39–45.
6. Werner, L. & Denning, J. (2009) Pair programming in middle school: What does it look like? *Journal of Research on Technology in Education*, 42 (1), 29–49.

Raspberry Pi

Benefits of this approach:

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https://raspberrypi-education.s3-eu-west-1.amazonaws.com/Quick+Reads/Pedagogy+Quick+Read+3+-+Pair+Programming.pdf

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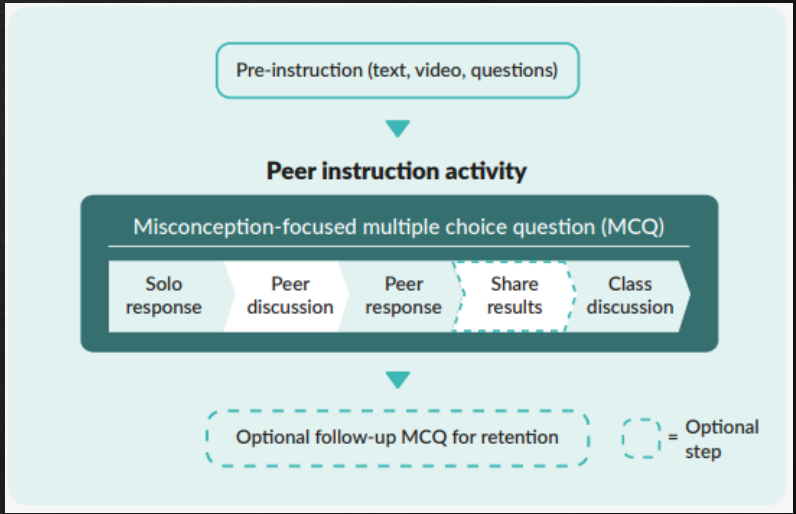
Peer Instruction

Peer instruction relies on carefully selected Multiple Choice Questions (MCQs) based on some pre-instruction material. In class, the MCQs are combined with peer discussion to explore and challenge student understanding.



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Peer Instruction

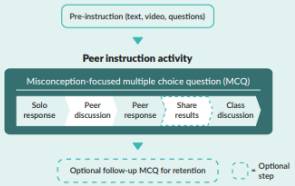
National Centre for Computing Education

Raspberry Pi

Pedagogy Quick Reads

Using peer instruction in lessons helps students learn, retain, and discuss computing concepts

Peer instruction (PI) is an instructional technique first proposed in the 1990s by Eric Mazur[1], whose research demonstrated the benefits of focused discussion for pupils' understanding and retention in physics. Subsequent studies have highlighted similar benefits of teaching using peer instruction in other subjects, including computing[2 3].



Summary

Peer instruction can replace a traditional presentation approach by combining pre-instruction, multiple choice questions, and peer discussion, to encourage deeper engagement with the content in question.

Benefits:

- It is a straightforward approach for educators to apply in their classrooms
- It leads to roughly double the learning gains when compared with no PI
- Learners value the PI approach — especially the discussion element
- Learners are more likely to retain key concepts and knowledge taught using PI
- Peer-led discussion promotes learning

Considerations:

- Peer instruction should follow some pre-instruction stimulus, ideally before the lesson
- Make sure that learners understand the rationale and benefits of PI
- Always encourage participation over correctness; PI is a tool for learning, not assessment
- Give learners challenging questions and time to discuss them
- Decide if you want to collect response data, and if so, how

What is peer instruction?

While the use of multiple choice questions (MCQs) is commonplace in classroom teaching, they are often only used for assessment. Peer instruction (PI) relies on carefully selected MCQs based on some pre-instruction material. In class, the MCQs are combined with peer discussion to explore and challenge student understanding.

Crucially, peer instruction begins with some form of pre-instruction (reading, videos, etc.), where learners can study and become familiar with the material in question before the discussion is held.

Peer instruction is carried out as follows:

1. The teacher poses a carefully selected MCQ. Learners have limited time to individually vote for their answer, using a method such as voting cards, clickers, or raising their hand.
2. Learners then discuss the question and their answers in small groups, aiming for a consensus.
3. The teacher displays the same question, and now, learners vote according to their group consensus.
4. Optionally, the teacher shares the results of both votes to highlight where responses have changed.
5. Finally, the teacher leads a class discussion about the question, sharing the correct answer and exploring the distractor.

The benefits of peer instruction

While most studies examining peer instruction have so far focused on its use in higher education, the practice offers many benefits which should transfer to other settings:

- Mazur[1] demonstrated that PI leads to significant learning gains for learners: those engaged with PI made up to twice as much progress as other learners. Similar effects have been found in subsequent studies[2], which also highlight the importance of the discussion element of PI.
- The same studies indicate that using PI in teaching helps students to retain knowledge.
- Once PI is part of the regular teaching practice, most students value the PI approach, recognise its benefits, value the discussion, and would recommend PI to their other teachers.[2]
- PI is fairly straightforward to implement, and evidence shows that even teachers who are new to the practice can quickly see its positive effects[2].
- Some researchers cite anecdotal evidence that PI may encourage learners to develop a growth mindset.[4]

What makes a good multiple choice question?

Good-quality MCQs are deceptively hard to write, as teachers have to predict what misconceptions their learners are likely to hold. For some topic areas, there are lists of known misconceptions; for others, teachers need to rely on their experience.

While there are no definitive rules for developing MCQs, these are some guidelines[5]:

- Questions should be clear and unambiguous
- Each question should test one concept only
- Learners should be able to answer questions quickly
- Teachers should learn something from each incorrect response
- It shouldn't be possible to answer correctly while still holding on to a misconception

Below is an example of a question. Can you identify the correct response and explain what might lead learners to select the incorrect responses?

Read the Python program below:

```
a = 1
b = a+1
print(b)
```

What will be the output of the program?

b	a+1	2	11

Considerations for applying peer instruction

- For many teachers and learners, classroom peer instruction represents a change in practice. It is important to be clear about the purpose of this approach and how it can benefit learners.
- PI isn't an assessment tool, but a means of instruction; educators should shift the focus away from getting the correct answers, and instead, promote the participation and discussion aspects of PI.
- A PI activity should be given as much time as possible, especially the discussion step, which should last at least 2–4 minutes[1]. This can feel like a long time, but it is time well spent.
- If using an online voting system — such as handheld clickers or web-based quizzes — the recorded data can be helpful in predicting which learners may require extra interventions.
- Consider how challenging a PI question is; questions should be challenging enough to promote discussion. Mazur suggests that best results are seen where 50% of learners get the initial question wrong[1].
- Pre-instruction is important. With older learners, a flipped approach is best, requiring them to prepare by reading, watching a video, etc. Where home learning is not possible, peer instruction activities should build on previous lessons, or even on content studied earlier in the lesson.

Where to start

- Review your content and highlight opportunities for pre-instruction. Consider what learning can be moved outside the classroom to enable discussion during the lesson.
- Review and trial some **existing multiple choice questions** using peer instruction to diagnose some of your learners' misconceptions.
- Write your own multiple choice question(s), describe the misconception that each answer addresses, and share the question(s) with other educators.
- Encourage learners to deepen their understanding of a topic by writing their own MCQ.
- Visit **Peer Instruction for Computer Science** for more guidance and resources.

References

1 Crouch, C. & Mazur, E. (2001) Peer instruction: ten years of experience and results. *American Journal of Physics*. 69(9), 970–977.

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5 Barton, C. (2017) *What makes a good Diagnostic Question?* Available from: https://medium.com/eedi/what-makes-a-good-diagnostic-question-b76f2a65e0320. [Accessed 3 December 2019].

Raspberry Pi

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https://girlswhocode.com/en-uk

https://projects.raspberrypi.org/en/codeclub

https://stemettes.org/

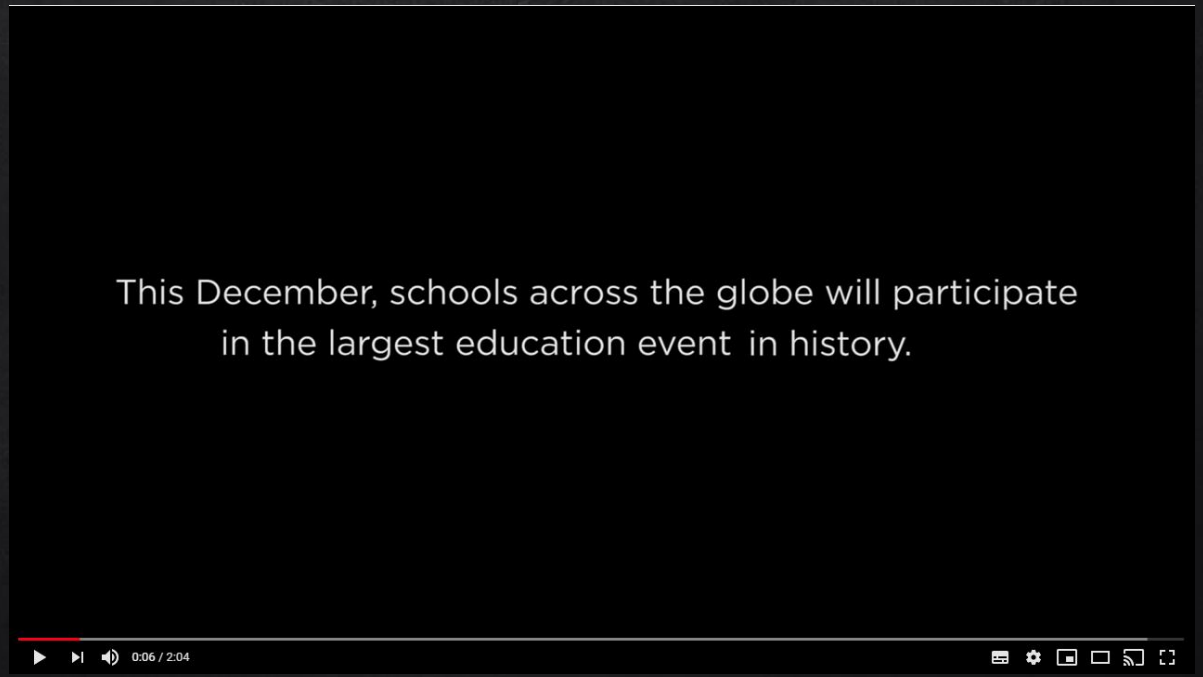
http://www.bebras.uk/

https://www.ncsc.gov.uk/cyberfirst/girls-competition

https://www.barefootcomputing.org/

CyberFirst Girls

Hour of Code



https://youtu.be/KsOIlDT145A

CAS

https://www.computingatschool.org.uk/

‘You cannot be what you cannot see’

Reshma Saujani

CEO and Founder of Girls Who Code

Women in Tech: Role Models

https://www.eventbrite.co.uk/e/careers-with-impact-meet-the-programmers-who-codetheworld-live-event-tickets-117522140887

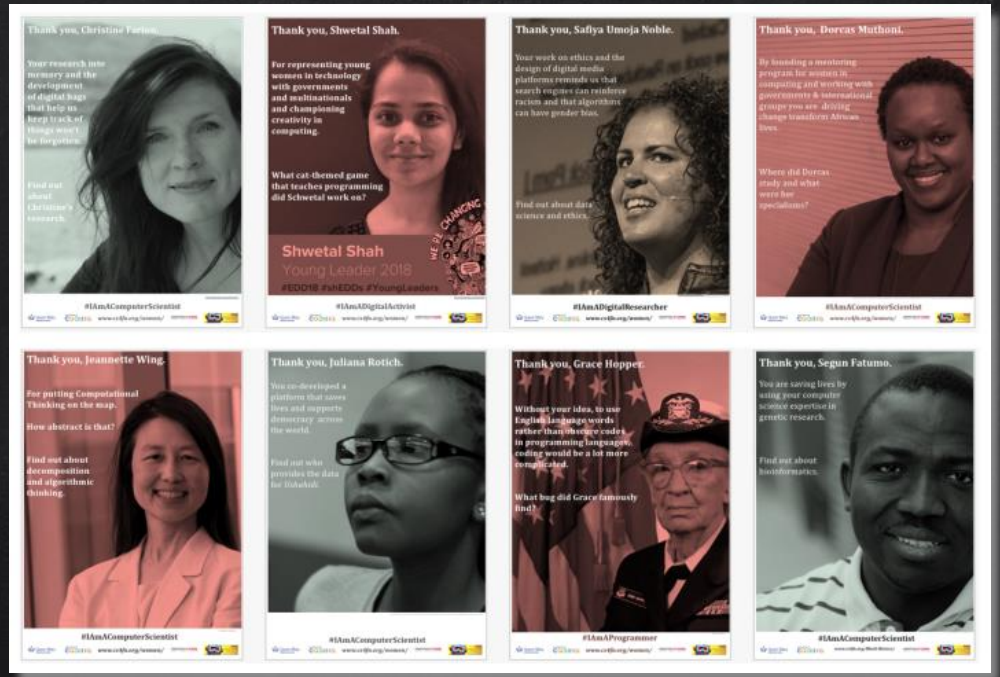
STEM AMBASSADORS

https://www.stem.org.uk/stem-ambassadors

Women in Computing

https://teachinglondoncomputing.org/2020/03/03/women-in-computing-free-posters-for-uk-schools-from-iocoding-digitalskillsmatter-jb/

DIVERSITY POSTERS



https://teachinglondoncomputing.org/celebrating-diversity-in-computing/

Own Posters

Gender Balance in Computing – GBIC

Register your school for Gender Balance in Computing

The Gender Balance in Computing (GBIC) project is a new programme of research. It is funded by the Department for Education and will be the largest national research effort to address gender balance in computing to date.

Please complete this form if you are a teacher or school leader interested in finding out more about the research programme and trials. As part of the GBIC Schools Network, you will have access to new materials developed through these interventions.

If you are an individual or an organisation, please do not complete this form. Instead, please click on this link where you will be able to subscribe to our newsletter: ncce.io/gbicgenreg

REGISTER YOUR INTEREST FOR OUR TRIALS

We are running a number of different projects with schools to explore effective ways of engaging female pupils in computing and increase the number of female pupils choosing to study computer science at GCSE and A level.

Please tell us which projects you are interested in taking part in. We will then contact you with more details so that you can understand the commitment involved before you confirm your participation. All projects can be delivered to both boys and girls in your class or year group.

Belonging (Primary) - Starting March 2021
The project is available for Year 5 teachers and their pupils and will test different approaches to providing STEM role models.

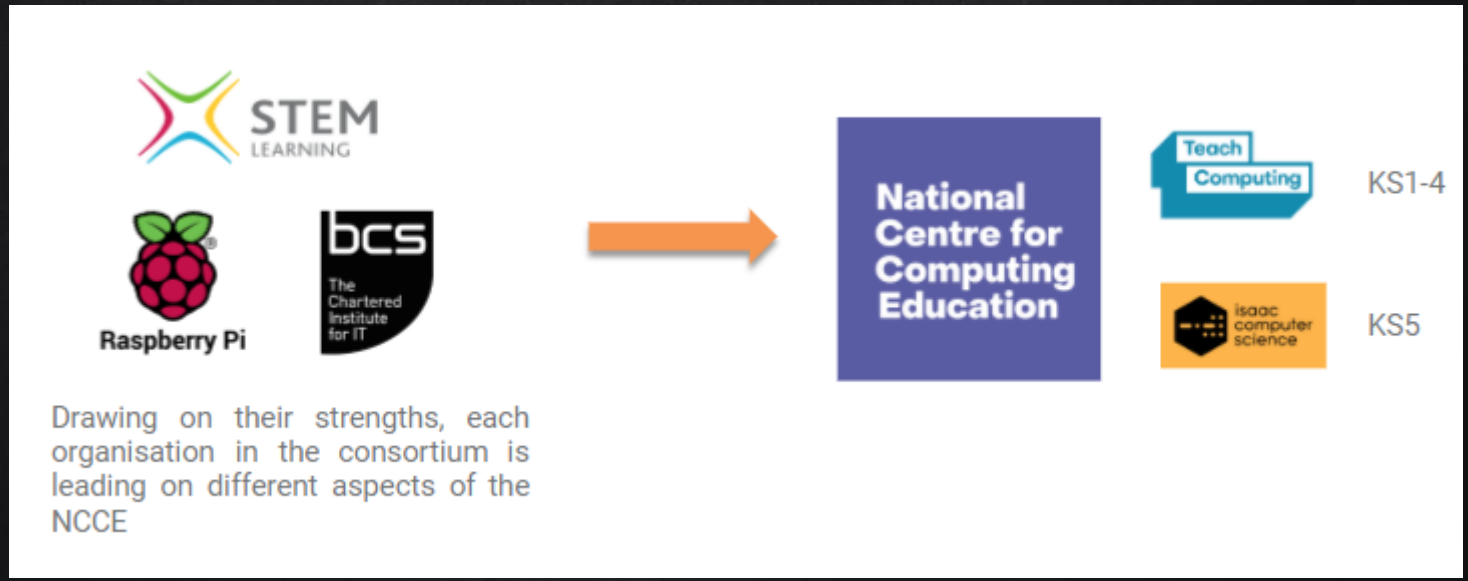
- ○ Yes, I am interested in taking part in this project
- ○ No, I am not interested in taking part in this project

Teaching Approach (Key Stage 1 Storytelling) - Starting April 2021
We are looking for teachers of Year 2 for this project. If your school is randomly allocated to test this approach, we will provide some free lesson materials to integrate storytelling approaches in your computing lessons.

- ○ Yes, I am interested in taking part in this project
- ○ No, I am not interested in taking part in this project

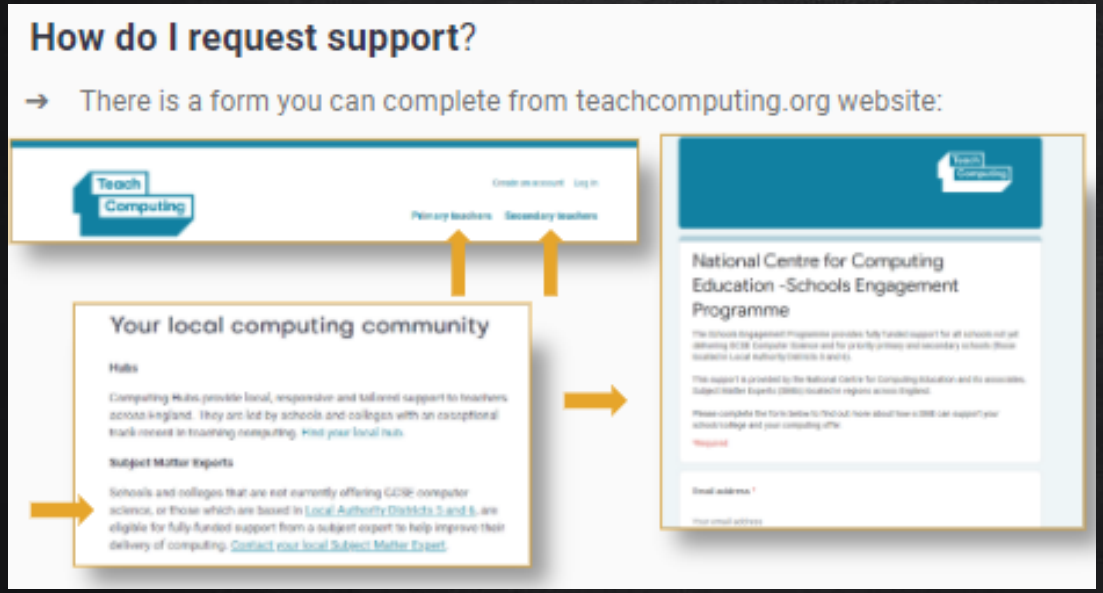
http://ncce.io/gbicregister

National Centre for Computing Education



https://teachcomputing.org/

NCCE: COURSES, SME SUPPORT & MORE



https://docs.google.com/forms/d/e/1FAIpQLSeSmJgi5jsUI0u6AxUR-FmEkudj-jgeGYLAVumaHgxGilEIw/viewform

https://teachcomputing.org/

Approaches for encouraging Diversity in your classroom

Deliver a creative curriculum

Use gender-neutral and culturally sensitive language and activities in your lessons

Be aware of your unconscious bias and how to avoid it

Provide accessible homework opportunities e.g. paper-based or provide lunchtime access to technology

Promote role models from diverse backgrounds.

Learn how to encourage and inspire all groups of students

Cover a broad Computing curriculum not just computer science

Do not enforce entry requirements for qualifications

Use techniques, like paired programming, to engage girls

Use free and open-source tools and resources, e.g. wiki books and free software

Thank You

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