Embedding collaborative practice in introductory programming courses

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- Topics include numerical analysis, statistics, data science, machine learning, optimisation...
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Combining collaborative learning and good practice

How can I promote peer learning and effective collaboration in an online programming class?

1. Synchronous:
    - **Pair programming** in problem-based labs
    - Live coding in lectures ("collaborative learning" with the lecturer)
    - Small group peer code review
2. Asynchronous:
    - Discussion board (Piazza)
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Pair programming and peer-assessed code reviews deployed in two courses:

- Semester 1: **Python Programming** (MSc, 250 students). Introductory Python course, focused on programming skills, overviewing some applications in applied maths and data science.
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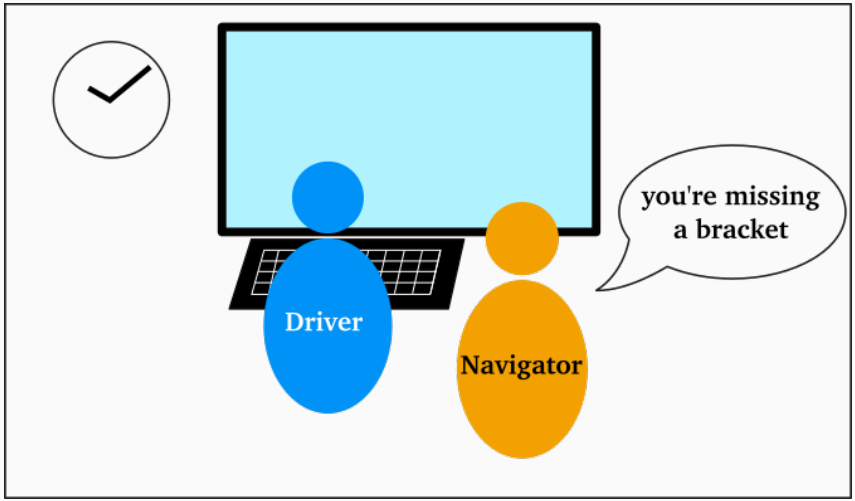
Pair programming as a pedagogical tool

The pair programming workflow



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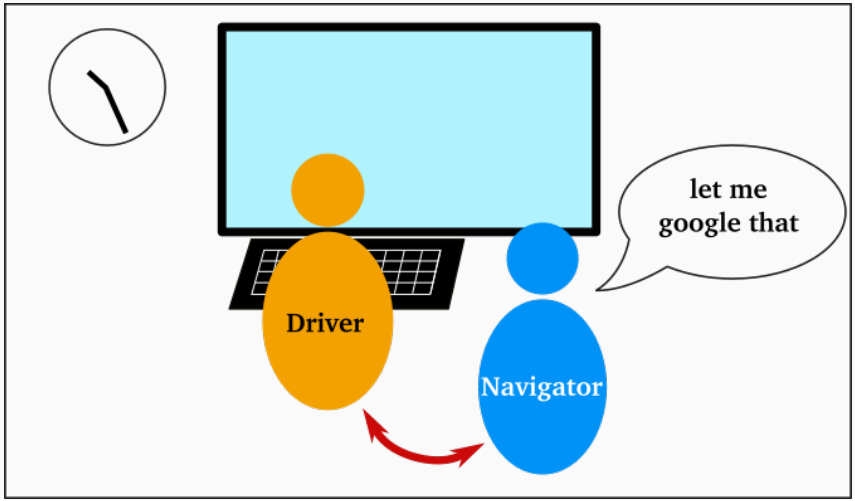

Motivations for trying pair programming

- **Small groups** (2 or 3): all students take an active role in solving the task, (have to) talk to each other.
- **Structured/scripted roles**: less time and cognitive effort spent on figuring out a way to collaborate efficiently/productively ("unscripted" collaboration can be particularly unnatural to navigate in a virtual "room").
- Tutors can't always "keep an eye" on the whole room and identify who needs help: working in pairs gives everyone an **immediately accessible source of help**, minimises tutor time spent on "trivial" mistakes (syntax errors, typos...).
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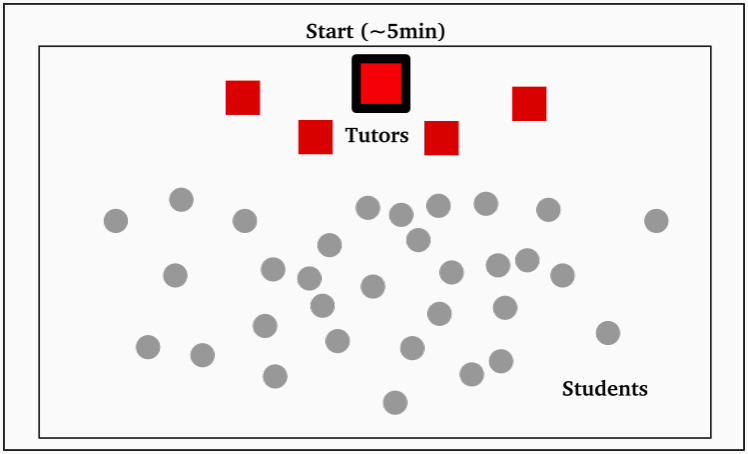
Distributed/remote pair programming

Session organisation



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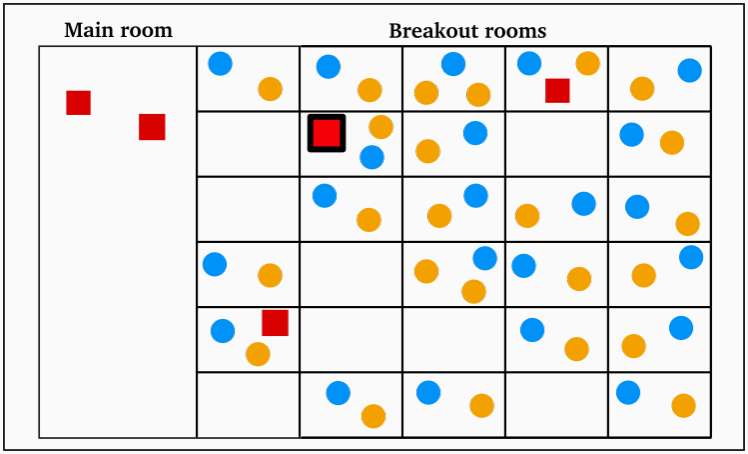
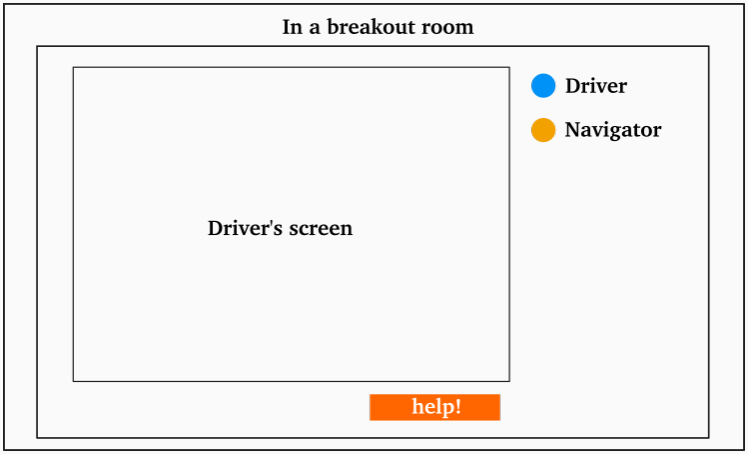


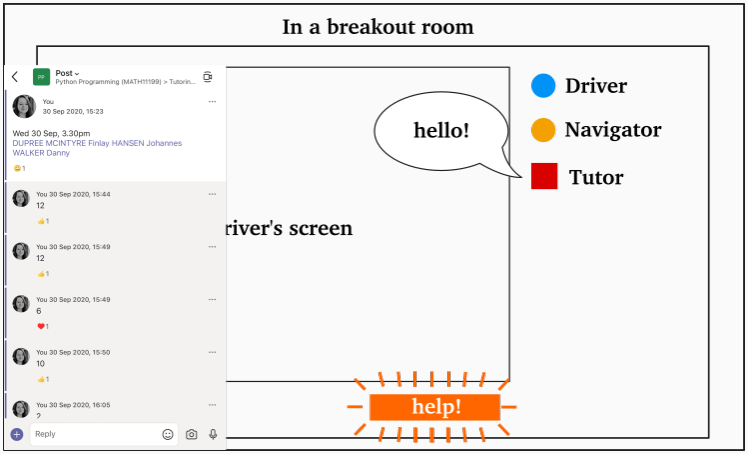
Inside a breakout room



Inside a breakout room

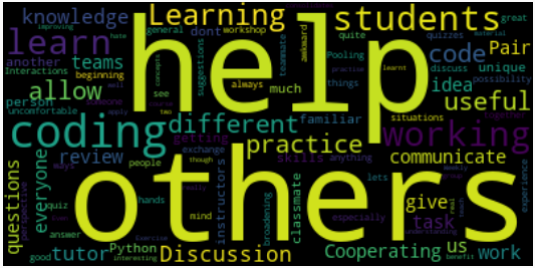
1. Driver **forks** a template GitHub repo containing the task; navigator joins the forked repo (easily set up with GitHub Classroom).
2. Driver **clones** the repo, shares their screen, and starts working on the task.
3. Navigator reads instructions, actively observes, talks to the driver, checks documentation...
4. They **switch roles** after $\sim$15 minutes. Old driver commits and pushes their changes, new driver pulls, shares their screen, and continues.

Getting help



How did it go?

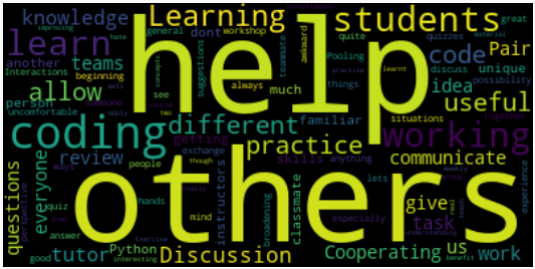
Student feedback: the positives



"What do you consider to be the most useful aspects of the workshops?"

- Most of the responses point at cooperation, discussion, peer learning as positive aspects.
- Other positive comments: the workshop tasks are interesting, I get to apply the skills I've learned, I can get good help from tutors.

Student feedback: the positives



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Student feedback: the positives

Some representative comments heard/read from students:

- "This is the most 'social' course I have" / "This workshop is my main social interaction for the week"
- "I didn't interact much with tutors since we often solved coding issues by ourselves. This is a good feature of the workshop."
- "[Workshops] allow you to have interaction with other students and help from tutors at the same time."
- "It was good to meet people and learn to pair program."
- "Peer (sic) programming is great. I'm not sure if this was a new addition to the course or not, but I hope it stays."
- "Working with others is also a real benefit as it allows you to learn from others, or teach others which further consolidates your own learning."

Student feedback: the negatives

- Most of the negative feedback on **pair programming labs** mentions the lack of time – 1 hour was too short.
- Some friction with technical issues, complicated workflow with git/GitHub/IDE for beginners, particularly at the start of the semester. This improved as the students got used to their tools.
- Some issues with **incompatible pairs**.

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Student feedback: the negatives

Some ad-hoc comments heard/read from students:

- "I didn't like the format (work in pairs) so I decided not to go to many of them."
- "There are a lot of tasks for the short time of the workshops usually. Also pair programming online is sometimes just watching another person googling something, so I'm not really sure if Pair Programming is the way to go for the workshops."
- "I found [the workshops] useful when I found a good group of people to work with."
- "Too much work not enough time. I would have benefited from a two hour workshop instead."

Incompatible pairs

As a "non-specialist" cohort, levels of programming experience (and even general computer literacy) vary immensely between the students coming into the course. Dysfunctional pairs were typically:

- very experienced + complete beginner (a frustrating experience for both),
- two complete beginners (got stuck very easily).

Zoom update in Autumn 2020 allowed attendees to choose their own breakout rooms. Issues with mismatched pairs and lack of confidence from beginners were greatly reduced by:

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Changes from 2021

Pair programming in the classroom

Broadly the same workflow!

- Students work from their own laptops.
- Students work in groups of 2 or 3. They choose who they work with.
- GitHub still used for sharing work; students are reminded to change roles every 15-20 minutes.
- From this year: GitHub Codespaces as a cloud computing environment (for now, free for teaching) — no need to install anything!

Pair programming in the classroom

- Easier to tutor!
- Student feedback still very positive.
- 2022: back to 2-hour workshops.
  - Tasks were kept the same as for the 1-hour workshops.
  - “Further work” was attempted by a lot more students.
  - Much fewer complaints about technical issues or having too little time.

Peer-assessed code review

Motivations for peer code review

- **Peer learning** by seeing how others have approached the same task.
- Building **good habits**: students are asked to assess robust testing, commenting and style, code structure...
- Helping to build a sense of **community**: students don't have as much opportunity to work and learn together.
- Introducing **standard professional practice**.
- Better understanding of the assessment process.

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Planning: 2020

- Code review tasks were alternating with quizzes as weekly homework (5-10% total grade).
- Set over 2 weeks: submit your solution by the end of the first week, peer-assess 3 submissions by the end of the second week.
- In code review weeks, the **synchronous lab** was a small group scaffolding + peer review activity:
  - Peer review only was not particularly successful. Students would be finished in quite a short time, and the submissions they had to actually assess were not those from their discussion group.
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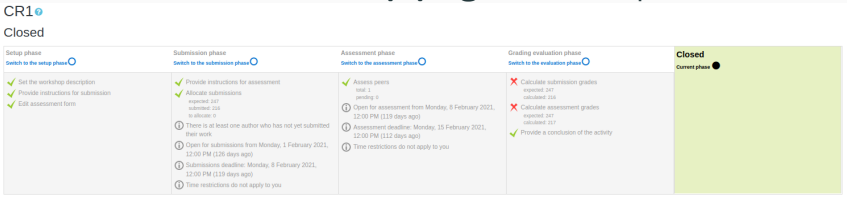

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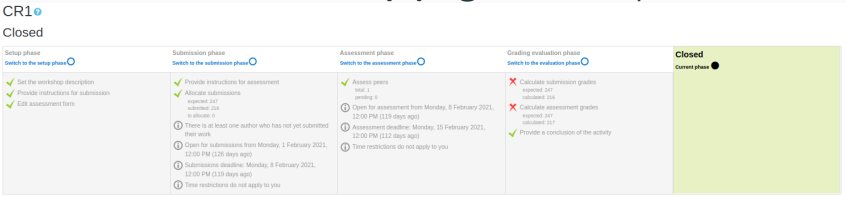

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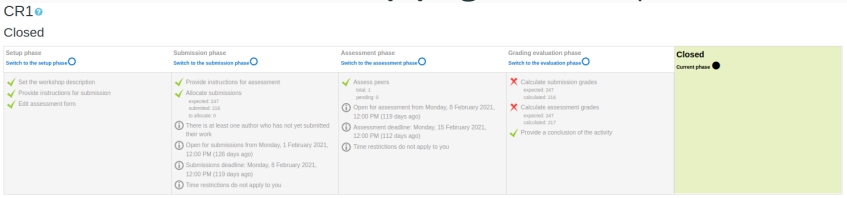

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Setup using Moodle Workshop

Moderation:

- As instructor, I could override grades, add my own assessment, or change weights of different assessments.
- I checked a sample of random submissions/assessments each week.
- I set up a form which students could use to request further instructor moderation.

Peer-assessed code reviews

Based on student feedback (workload, scaffolding, workshop discussions):

- Submit **solution to quiz question** for peer-assessment.
  - Much less added workload (assuming the quiz is completed).
  - Burden of assessing **correctness** is taken away from students.
  - Focus on readability, commenting, structure, efficiency.
- Provide **instructor-assessed examples** to go through before peer assessment.
  - Provides an element of self-assessment/calibration before peer assessment.
  - Provides examples of what constructive feedback looks like.
  - Provides opportunity to highlight common shortcomings.

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Communities of practice

Pair programming club has been meeting up regularly since the summer.

We're an informal group of lecturers and tutors teaching programming labs in a wide range of disciplines at the University of Edinburgh (for now!). We meet together to try different ways to pair-program, to discuss how it works in our respective courses, and to address specific questions and challenges.

There are **many different ways** (and tools) to set up pair programming in your classroom.

There is no commitment – join whenever you want if you're interested in trying pair-programming!