# Rationale/background

- Problem solving is highly valued in science, and is a skill required for success in our undergraduate genetics courses.
- We knew very little about the problem solving processes our students use in genetics, and how that compares to successful solvers/experts.
- However, it is uncommon for problem solving skills to be explicitly taught and assessed in our courses.

# Research Questions:

- What processes/procedures do students use when solving genetics problems, and how does this compare to experts?

- Can we improve student problem solving by making it an explicit part of our course curriculum?

# Study Design

- Initial think-aloud interviews were conducted, and responses coded, to determine typical student and "expert" problem solving behaviour
- Subsequent think-aloud sessions were used to assess student problem solving behaviour
- Student responses on quizzes, tutorial questions, and exams were also assessed for demonstration of problem solving

| | Control: Typical Course | Treatment: Problem Solving 1 | Treatment: Problem Solving 2 |
|---|---|---|---|
| **Total Class size** | N=180 | N=390 | N=74 |
| **Think-aloud group size** | N=21 | N=11 | N=10 |
| **Class CI pre-test mean (s.d.)** | 47 ± 20% | 36 ± 19%* | 46 ± 23% |
| **Think-aloud group CI pre-test mean** | 48 ± 19% | 31 ± 16%* | 54 ± 16 % |
| **Teaching Problem Solving (PS) Process** | No | Yes | Yes |
| **Practice PS + feedback** | Not explicit | Not explicit | Yes, prompted |
| **Assessed on PS steps** | No | No | Yes |

*significantly lower than the control and PS2 group

# Results: Problem Solving Process

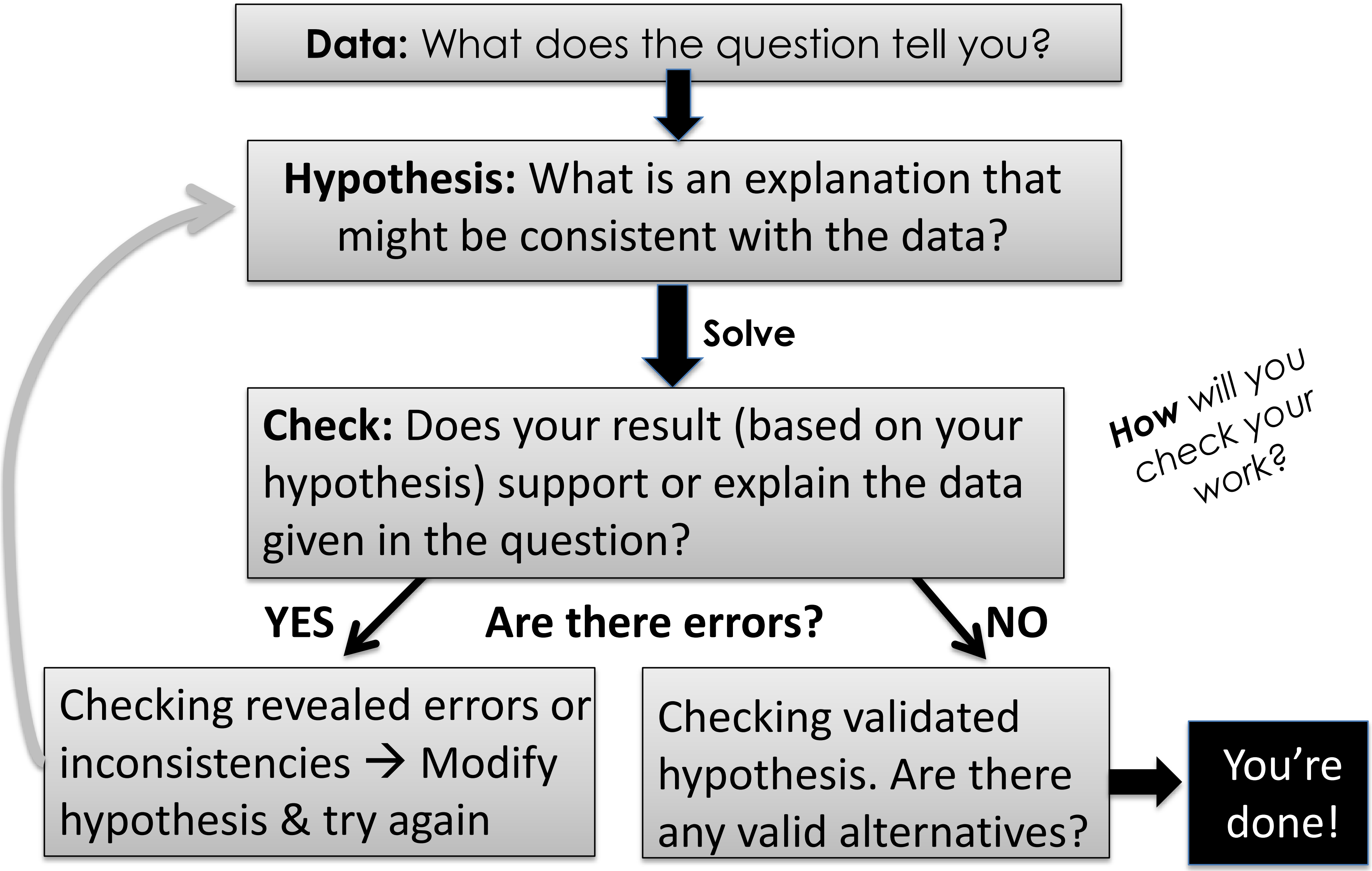
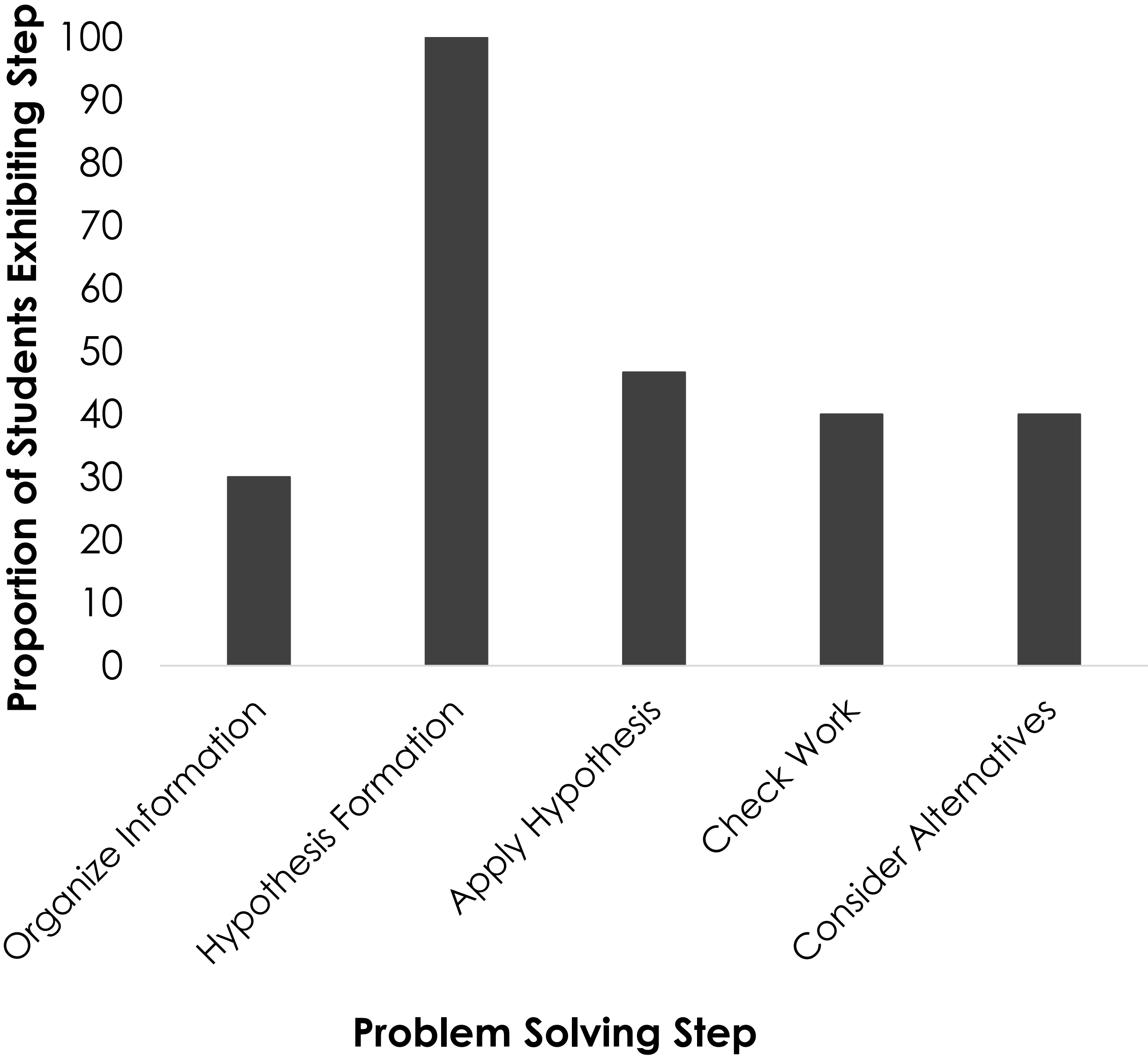



*Figure modified from Rosie Redfield's*

# What do students typically do?




From Think Aloud Interviews (control group):

- Students rarely check their work or consider alternative solutions
- Interviews revealed that many students don't know *how* to check their work

**Part c:**
A third, unique phenotype appears in the F2 (a phenotype that was not observed in the parents or the F1). This new phenotype is observed in more than one F2 individual. Provide a possible genetic explanation for this. Show your work.

| Expert/Successful | | Unsuccessful | |
|---|---|---|---|
| Revisit solution to part a and b, confirming what phenotypes and genotypes are present. | Organizing information | No apparent consultation of what genotypes and phenotypes were observed in F1 and F2. | |
| Second gene involved. Recessive homozygous masks the colour locus. Assigning new genotypes to parents and F1, e.g. parents are both heterozygous at a second locus. | Hypothesis formation | First hypothesis: random mutation. | Hypothesis formation |
| Performing crosses: P x P → F1 and F1 x F2 → F2. Determining phenotypes observed based on hypothesis. | Doing work | A random mutation wouldn't account for seeing this new phenotype in more than one F2. | Checking: comparing outcome of hypothesis to criteria given in question |
| Homozygous recessive would be observed in F1, new phenotype. Does not fit criteria | Checking work | Second gene. Homozygous recessive epistatic to colour locus. Parents heterozygous. | Hypothesis formation |
| Revise hypothesis. Only one parent is heterozygous at the second locus. | Hypothesis formation | Erroneous solution accepted. | Lack of applying hypothesis and checking outcome against criteria given in question. Insufficient solution. |
| Performing crosses. New phenotype only observed in F2. | Doing & checking work | | |
| No immediate likely alternatives come to mind. | Evaluation. Solution accepted. | | |

# Problem Solving & Success

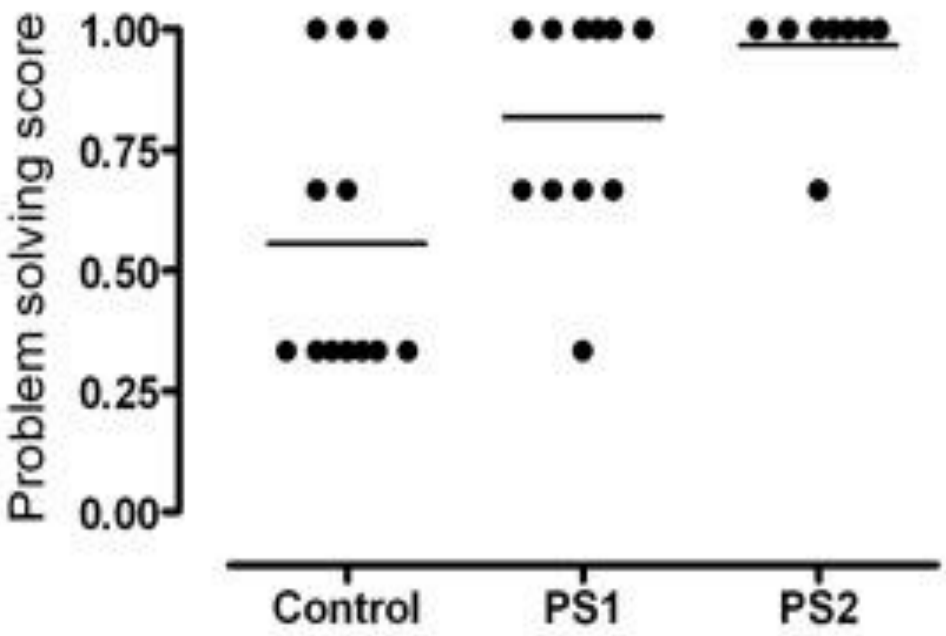

*Interviews:*

- "work-checking" students were typically more successful at solving a problem, or at least recognizing errors.

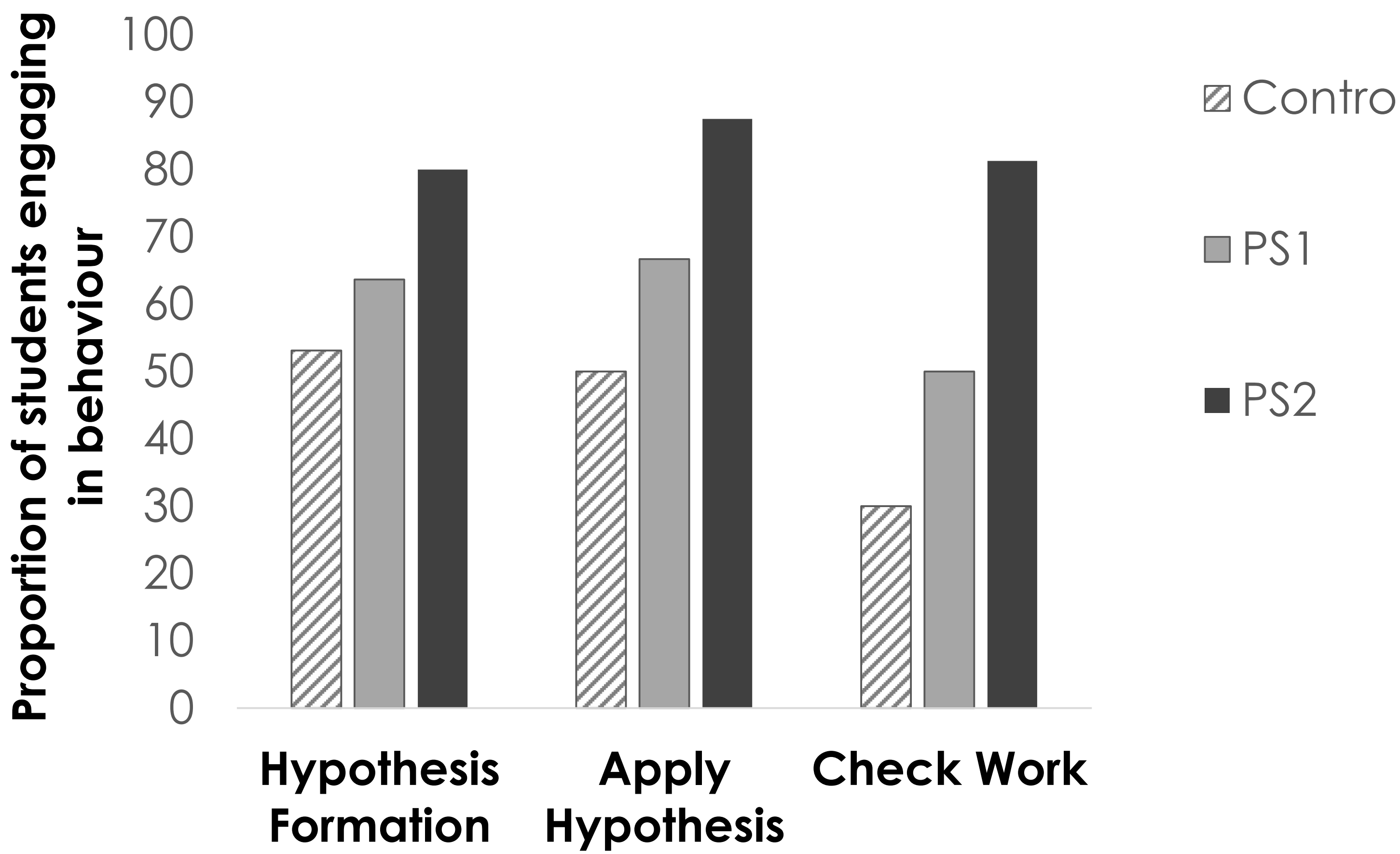
*Quiz answers:*

- Students who demonstrated work-checking typically get a better mark.

# Results: Students better at solving




- Each dot represents a student.
- Students were assigned a problem solving score, based on demonstration of identified "expert-like" behaviours.
- More of the interviewed students exhibited problem solving behaviours if they were from the full problem solving treatment group (PS2)




- For this particular question, the overall increases in total problem solving score for the PS2 groupare the result of increases in all behaviours, primarily work-checking.

# Conclusions

- Many students do not use work-checking and considering alternatives automatically, and often they do not know how to check work.

- Engaging in “expert-like” problem solving processes is correlated with success.

- Integrating problem solving into the course curriculum may increase the number of students that engage in problem solving behaviour automatically.

- Assessment and rewards may be the key to students engaging in the desired behaviours.

# Outstanding Questions

- How can we easily, and accurately, assess context-dependent problem solving skills?
  - Capture data from a larger population, without doing think-aloud interviews

- Is work-checking a metacognitive behaviour? Are there better ways to foster this behaviour (other than grades as incentive)?

- Do students transfer these skills to other courses or contexts?

# Acknowledgements

Thank you to

- Jennifer Klenz for supporting this work in BIOL 234.
- 234 students who volunteered for think-aloud interviews.
- Craig, Pam, Jennifer, and Shannon for volunteering as “experts”
- Ashley Welsh for providing advice on think-aloud interviewing and coding
- Carl Wieman, Sarah Gilbert, Trish Schulte and the STLF team for feedback