Sense of Belonging in Undergraduate Computer Science

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Sense of Belonging or Belongingness

- A personal belief that one is an accepted member of an academic community whose presence and contributions are valued.
- Belongingness is associated with progression, motivation, achievement, persistence, retention and student well being.
- Belongingness has been shown to vary with gender, race, nationality, LGBTQIA+, socio-economic status, religion, disability, and other factors.

Early considerations

- We were interested in our students' belongingness and wanted to learn more about it
- All we had were our students (and an instrument).
  - Non-probability sampling
    - Purposive (judgemental) and homogeneous
- Our results are therefore tightly coupled with our context
  - We know we have a selection bias and don't know how well our sample represents the population
- There are also questions we knew we couldn't answer 'in-house'
  - Designing an approach that could provide deep insight locally, but that could be expanded across multiple institutions and regions to answer those questions was a challenge (and also involved some luck)

Where did we start?

- We started the Sense of Belonging surveys in April 2017
- Computer Science undergrads in the UCD School of Computer Science
- 88 responses (~20%)
- Initially, we were very focused on gender, in particular women
- It quickly became apparent that it really isn’t about gender, but about the intersectional experience of gender and identifying as minoritised

What have we done so far?

- We ran the survey again in 2019 (three times!)
  - April 2019 (n=25)
  - June 2019 (n=10)
  - December 2019 (n=7)
- Disappointing response rates… but still provided some useful information…

What have we done so far?

- In August 2020 we ran the survey again
- UCD was shut down on March 13th 2020
- Students had been online for the final half of the last semester
- 68 responses (~15%)
- Showed dramatic changes in the sense of belonging of students

What have we done so far?

- In 2021 we extended the surveys across the College of Science
- Seven schools:
  - Computer Science
  - Chemistry
  - Earth Sciences
  - Mathematics & Statistics
  - Physics
  - Biology & Environmental Science
  - Biomolecular & Biomedical Science
- All undergrads, stages/years (1-4)

What have we done so far?

- In 2022/23 we extended the surveys across the Island of Ireland
- INGENIC: Irish Network for Gender Equality in Computing
- Founded in 2017 with the aim to unite, coordinate, and improve efforts in addressing Gender Equality in Computing across all third-level institutions in Ireland
- https://ingenic.ie/
- All HEIs with a CS/Computing department in Ireland and Northern Ireland are represented
- In 2023/24 we are extending the surveys across England, Scotland & Wales

How did we do it?

- Team/Collaborators
- Survey
- Ethics
- Roll-out surveys and fret about response rates
- Results to date
- Dissemination

Team (UCD)

- 2017-2020 Catherine and Brett
- 2022- + Shamima Nasran Runa (MSc, and soon to be PhD, student)
- 2023- + Andrew McCartan (UCD PostDoc – PhD Geography/Social Sciences)

Collaborators

- 2020/21 – Trinity College Dublin
- 2021/22 – UCD College of Science collaborators
- 2022/23 – INGENIC: Ireland & Northern Ireland (25 institutions)
- 2023/24 – Australia
- 2023/24 – England, Scotland, Wales
- 2023/24 – USA (Berkeley? :))

The Instrument: Sense of Belonging Survey

- “Sense of Belonging” questions are adapted from the “Math Sense of Belonging Scale” (Good et al.).
  - 18 positively framed and 12 negatively framed questions.
  - Participants rated their agreement on an 8 point Likert scale.
  - 1:Strongly Disagree to 8: Strongly Agree.
- Other questions have been added to (and removed from) the survey over the years, but the 30 core Sense of Belonging questions have remained the same.

“Math Sense of Belonging Scale”, in “Why do women opt out? Sense of belonging and women's representation in mathematics.” Good, C., Rattan, A., & Dweck, C. S. (2012).

As a student in the UCD School of Computer Science

18 positively framed questions:

1. I feel that I belong to the computer science community.
2. I consider myself a member of the computer science world.
3. I feel like I am part of the computer science community.
4. I feel a connection with the computer science community.
5. I feel accepted.
6. I feel respected.
7. I feel valued.
8. I feel appreciated.
9. I feel like I fit in.
10. I feel at ease.
11. I feel comfortable.
12. I feel content.
13. I feel calm.
14. I enjoy being an active participant.
15. I trust the testing materials to be unbiased.
16. I have trust that I do not have to constantly prove myself.
17. I trust my instructors to be committed to helping me learn.
18. Even when I do poorly, I trust my instructors to have faith in my potential.

As a student in the UCD School of Computer Science

12 negatively framed questions:

1. I feel like an outsider.
2. I feel disregarded.
3. I feel neglected.
4. I feel excluded.
5. I feel insignificant.
6. I feel anxious.
7. I feel tense.
8. I feel nervous.
9. I feel inadequate.
10. I wish I could fade into the background and not be noticed.
11. I try to say as little as possible.
12. I wish I were invisible.

SoB Score

- (sum of positively-framed responses) minus (sum of negatively-framed responses)
- *Relative and Arbitrary**
  - One SoB score in isolation really doesn't mean much. But they can be compared relative to one another.
    - *For this reason, consistency in the core questions is key. Change the core and comparisons start to get tenuous*
  - Min: -78
  - Max: 132
  - Midpoint: 27

*This was a decision made by Good et al. – and it's not as bad as it sounds at first (not being centered on 0, etc.)

Other questions & changes over time

- What School are you in? (since 2017)
- What stage/year are you in? (since 2017)
- What is your gender? (since 2017)
- How do you define your race/ethnicity? (since 2020)
- Do you consider yourself part of a minority in Computer Science *because of your gender, age, race, disability, ethnic origin, religion, sexual orientation, civil status, family status, membership of the Traveller community, socio-economic status, or for any other reason*? (since 2017, wording changed in 2020)
- If you said yes to the last question, what minority group(s) do you identify with? (since 2017)
- What was your access route into UCD? (since 2022)

Other questions include

- How much do you interact socially with other students in Computer Science? (since 2017)
- Are you a member of any UCD clubs or student societies, for example, *Women+ in STEM, Women@CompSci, NetSoc, International Students Society, LGBTQ+ Society, Mature Students Society*? (since 2017)
- Do you live: in rented accomodation/on-off campus/with parents (since 2023)
- If you don't live on campus, how far do you live from campus? (since 2023)
- Do you attend most of your classes/lectures/tutorials, etc. in person or online? (since 2023)

Other questions include

- In your opinion, how much does success in Computer Science depend on inherent ability i.e. it is something you are born with? (since 2017)
- How much do you enjoy problem solving? (since 2017)
- How confident are you in your maths abilities (2017-2020)
- How confident were you in your maths abilities before joining Computer Science? (since 2022)
- How confident are you in your maths abilities now? (since 2022)
- How much experience with Computer Science did you have before you came to UCD? (check all that apply) (2017-2020)
- How much programming experience did you have before joining Computer Science? (since 2023)
- How confident were you in your programming abilities before joining Computer Science? (since 2023)
- How confident are you in your programming abilities now? (since 2023)

Additional open ended questions

- Do you have any concerns or issues that you would like to share with me regarding gender balance/diversity/inclusion in the UCD School of Computer Science? Are there any initiatives or interventions that you would like to see implemented to help address your issues and concerns? Do you have any additional comments? (2017-2020)
- Is there anything that has positively or negatively impacted your Sense of Belonging in the School of Computer Science? (since 2022)
- Are there ways that you think that Sense of Belonging might be improved in the School of Computer Science? (since 2022)

Distribution

- Once we had designed the survey we applied for ethics approval from the UCD Human Research Ethics Committee
- Difficult at first, but got easier every time we reapplied (i.e. every time we extended the survey)
- Roll-out surveys and fret about response rates
- Responses gathered via a Google form
- Advertised on VLE, posters, student social media groups, students societies and clubs, etc.

Results/Insight

Notes:

- Students self-identified as a minority or not in the context of the School of Computer Science or the College of Science.
- Students self identified/self described their gender and race/ethnicity/nationality.
- Although nonbinary and trans students, and those who did not wish to disclose their gender, are included in most cases we report findings for men and women only, to preserve anonymity.

UCD School of Computer Science – Pre-pandemic 2017-2019

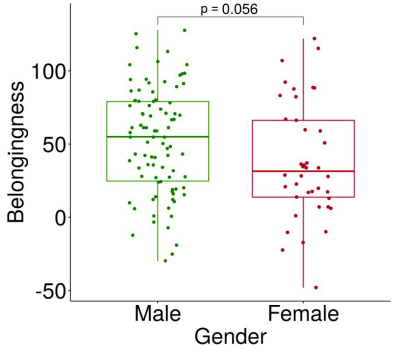
- Lower Sense of Belonging in minoritised women.
- Non-minoritised women had a Sense of Belonging comparable to non-minoritised men.
- Women involved in networking, outreach, and mentoring activities had a higher Sense of Belonging.

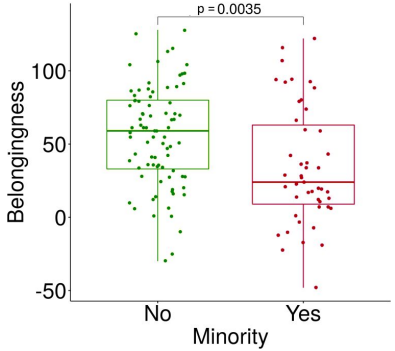
Catherine Mooney, Anna Antoniadi, Ioannis Karvelas, Lána Salmon, and Brett A. Becker. 2020. Exploring Sense of Belonging in Computer Science Students. In Proceedings of the 2020 ACM Conference on Innovation and Technology in Computer Science Education (ITiCSE '20). https://dl.acm.org/doi/10.1145/3341525.3393974

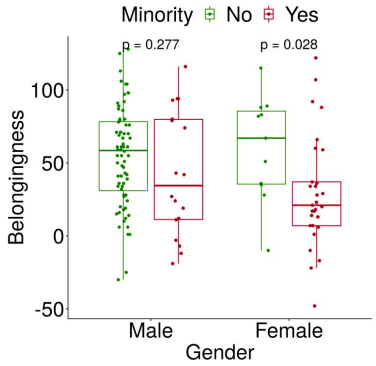
Catherine Mooney and Brett A. Becker. 2020. Sense of Belonging: The Intersectionality of Self-Identified Minority Status and Gender in Undergraduate Computer Science Students. In United Kingdom & Ireland Computing Education Research conference. (UKICER '20). https://dl.acm.org/doi/10.1145/3416465.3416476

*available open-access at brettbecker.com/publications

UCD School of Computer Science – Pre-pandemic 2017-2019







A: Borderline statistically significant lower level of Sense of Belonging in women compared to men.

B: Significantly lower Sense of Belonging in students who are minoritised compared to those who are not.

C: Belongingness is not significantly lower in minoritised men compared to non minoritised men. Minoritised women did have a significantly lower belongingness compared to non minoritised women.

D: Dramatically lower belongingness in minoritised women when compared to non minoritised men.

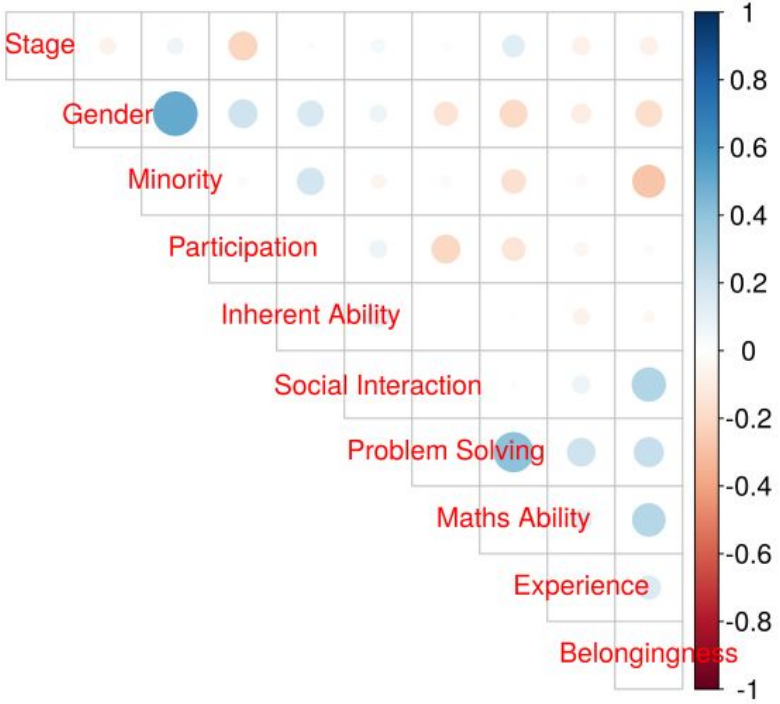
UCD School of Computer Science – Pre-pandemic 2017-2019

Correlation Matrix. Positive correlations (Pearson correlation coefficient (r)) are displayed in blue and negative correlations in red.

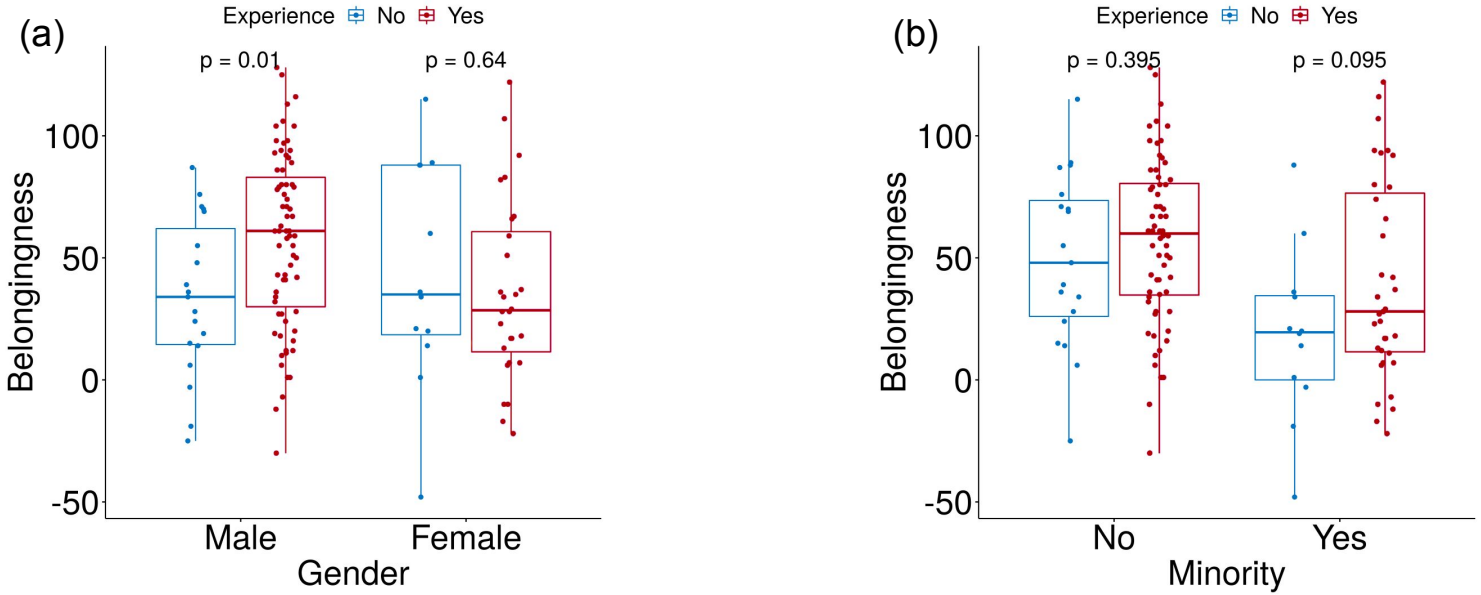
Colour intensity and the size of the circle are proportional to the correlation coefficients.

Gender is coded as Man: 0, Woman: 1

Minority is coded as No: 0, Yes: 1.

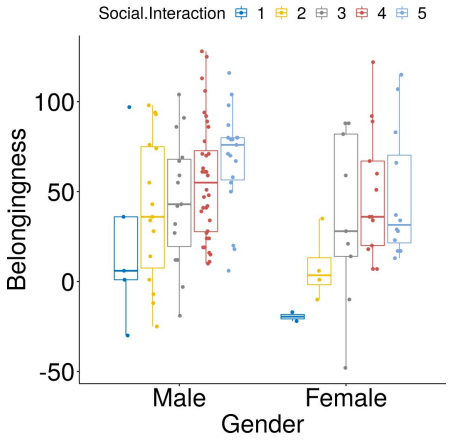


UCD School of Computer Science – Pre-pandemic 2017-2019

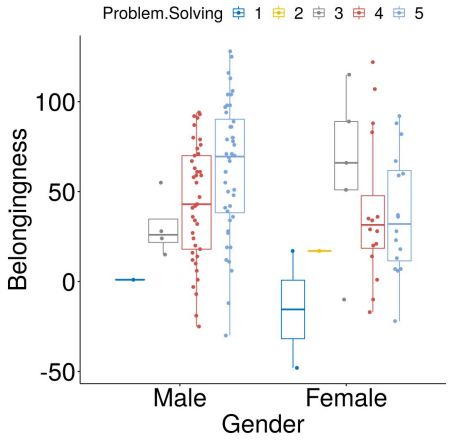


How much experience with computer science did you have before you came to University?
Broken down by (a) gender and (b) by identifying as a minority or not.

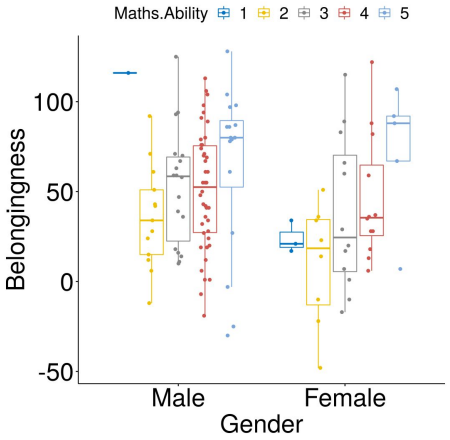
UCD School of Computer Science – Pre-pandemic 2017-2019



How much do you interact socially with other students in Computer Science?

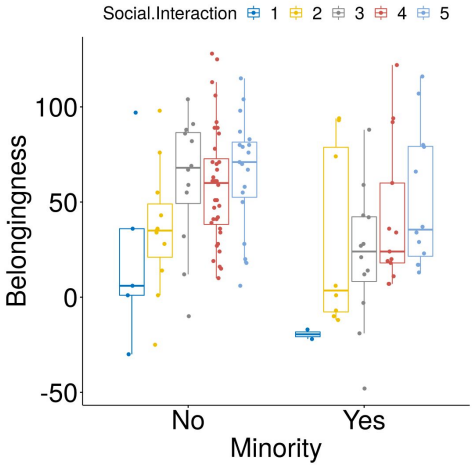


How much do you enjoy problem solving?



How confident are you in your mathematics abilities?

UCD School of Computer Science – Pre-pandemic 2017-2019



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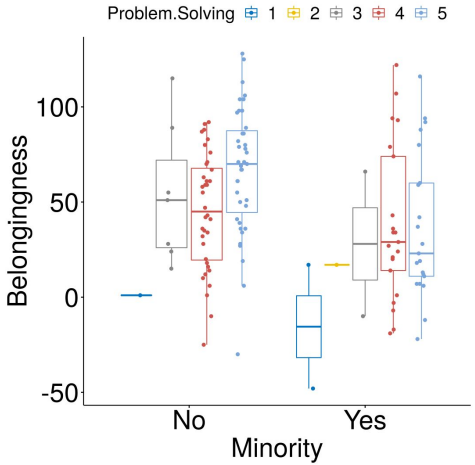

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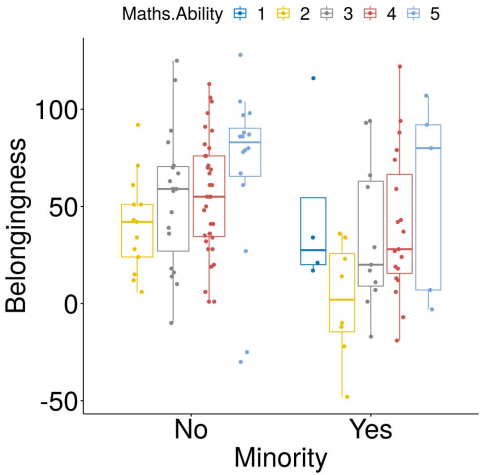

How confident are you in your mathematics abilities?

UCD School of Computer Science – Post-pandemic onset (2020)

- Investigated the impact of the pandemic on Computer Science students Sense of Belonging (August 2020).
- Provided evidence that the shift from in-person to remote learning dramatically affected the Sense of Belonging of CS students.
- This effect varied between genders and whether students self identified as being minoritised.

Catherine Mooney and Brett A. Becker. 2021. Investigating the Impact of the COVID-19 Pandemic on Computing Students' Sense of Belonging. In Proceedings of the 52nd ACM Technical Symposium on Computer Science Education (SIGCSE '21). https://dl.acm.org/doi/10.1145/3408877.3432407

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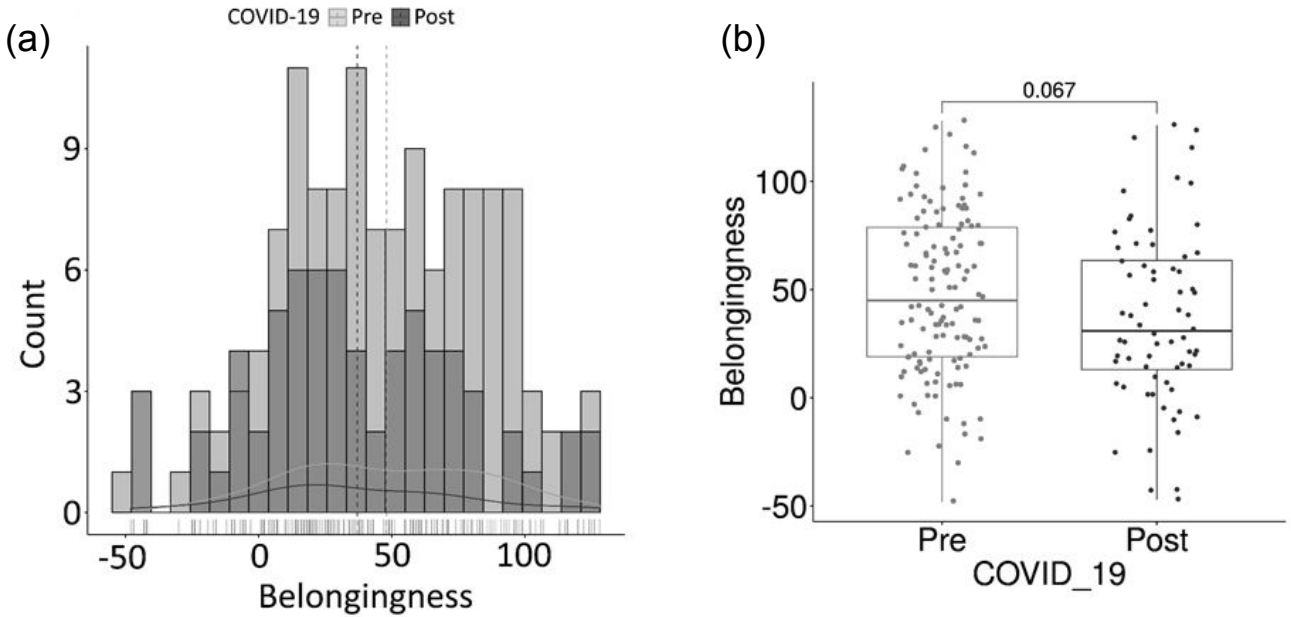
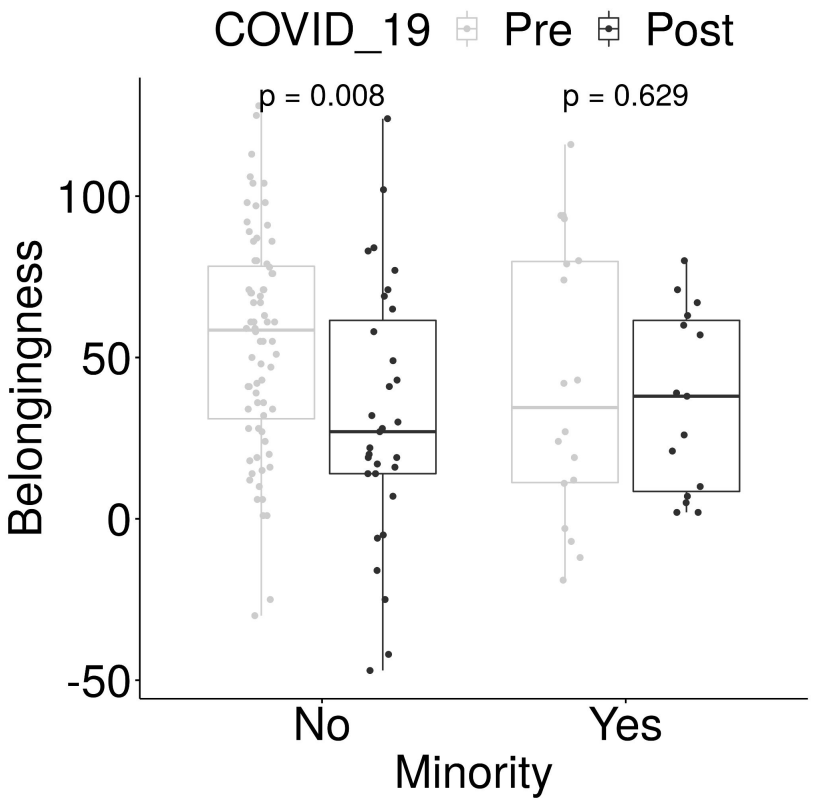
UCD School of Computer Science – Post-pandemic onset (2020)



Histogram (a) and boxplot (b) showing the distributions of belongingness scores broken down by the time the survey was completed i.e. pre-/post-COVID-19 (onset).

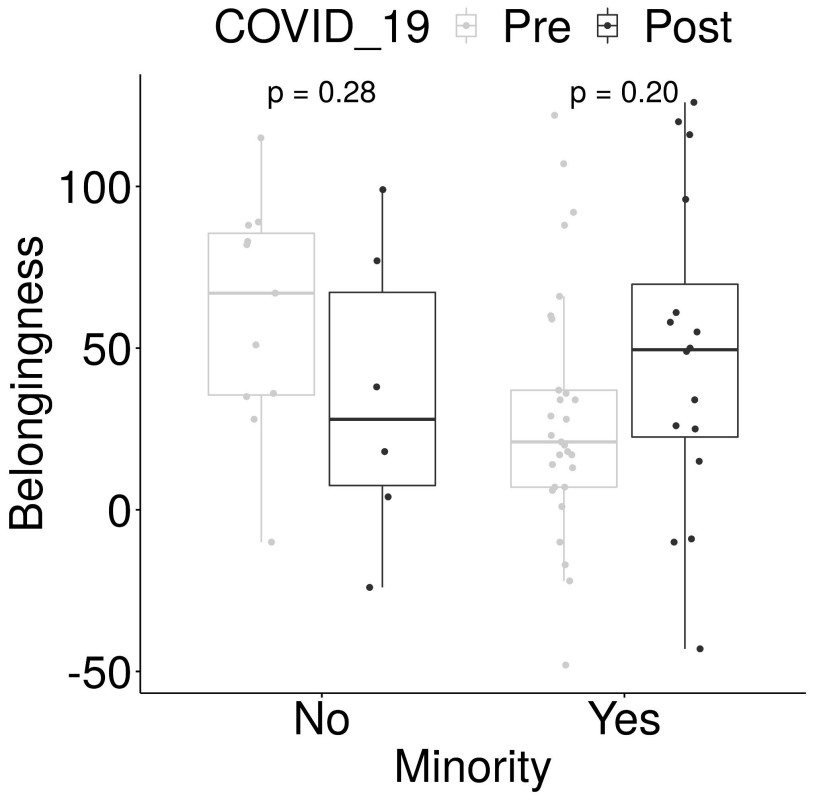
Men: Pre vs Post COVID-19 onset

- Non-minoritised men had a statistically significant lower mean belongingness post-COVID-19 onset compared to pre-COVID-19 onset.
- Minoritised men had an slight increase in mean belongingness post-COVID-19 onset compared to pre-COVID-19 onset, however this difference was not statistically significant.



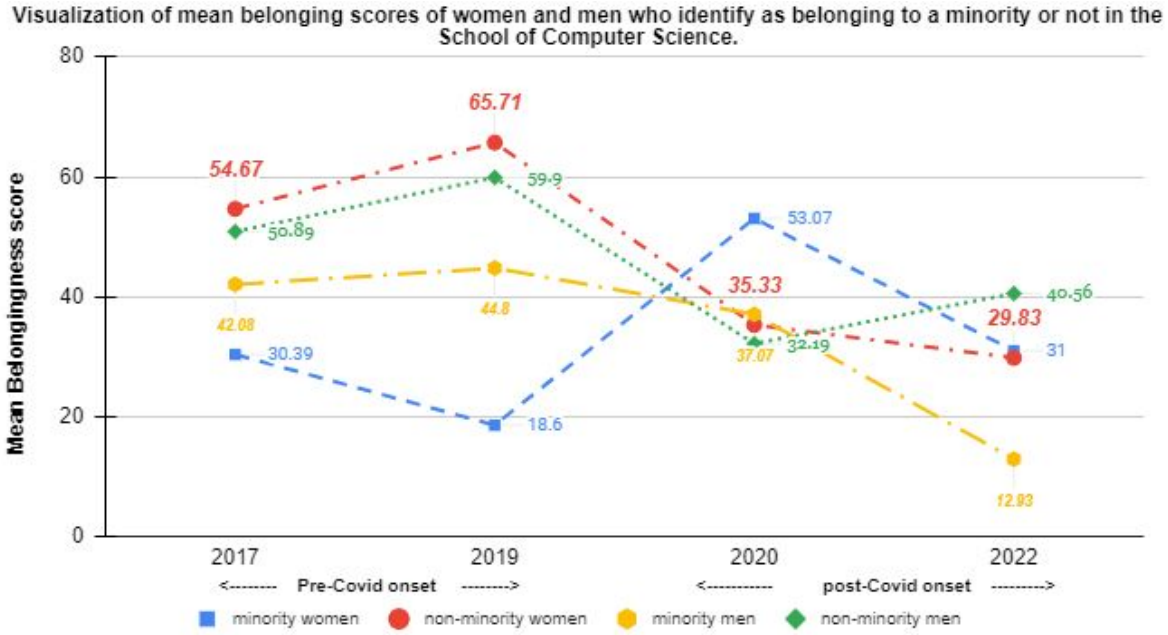
Women: Pre vs Post COVID-19 onset

- Non-minoritised women had a lower mean belongingness post-COVID-19 onset compared to pre-COVID-19 onset that was not statistically significant.
- Women that identified as being minoritised had an increase in mean belongingness post-COVID-19 onset, however this difference was not statistically significant.



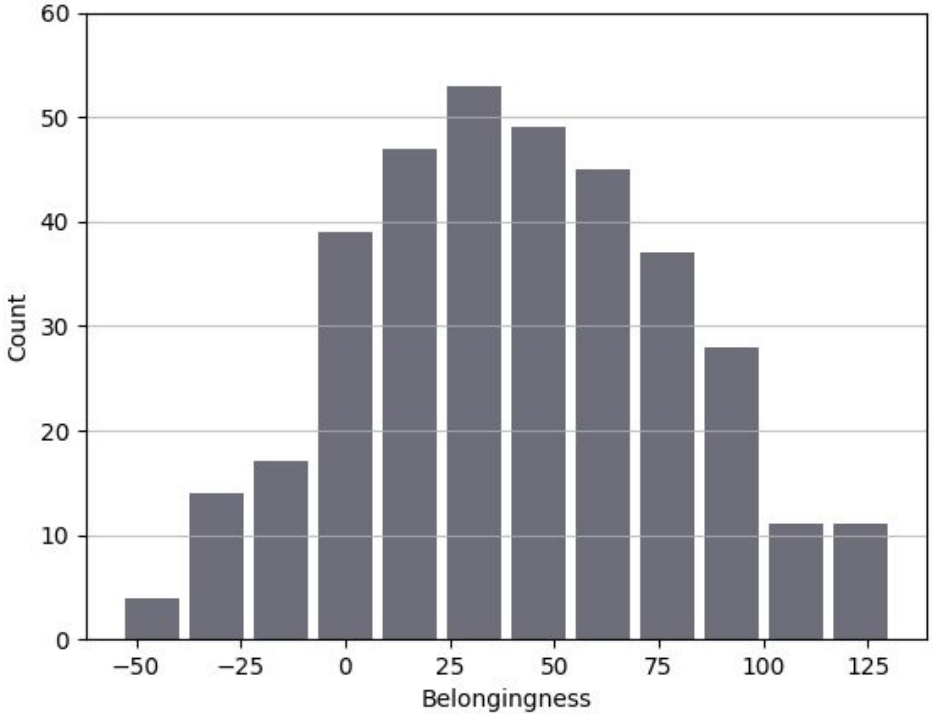
Changes in belongingness from 2017-2022

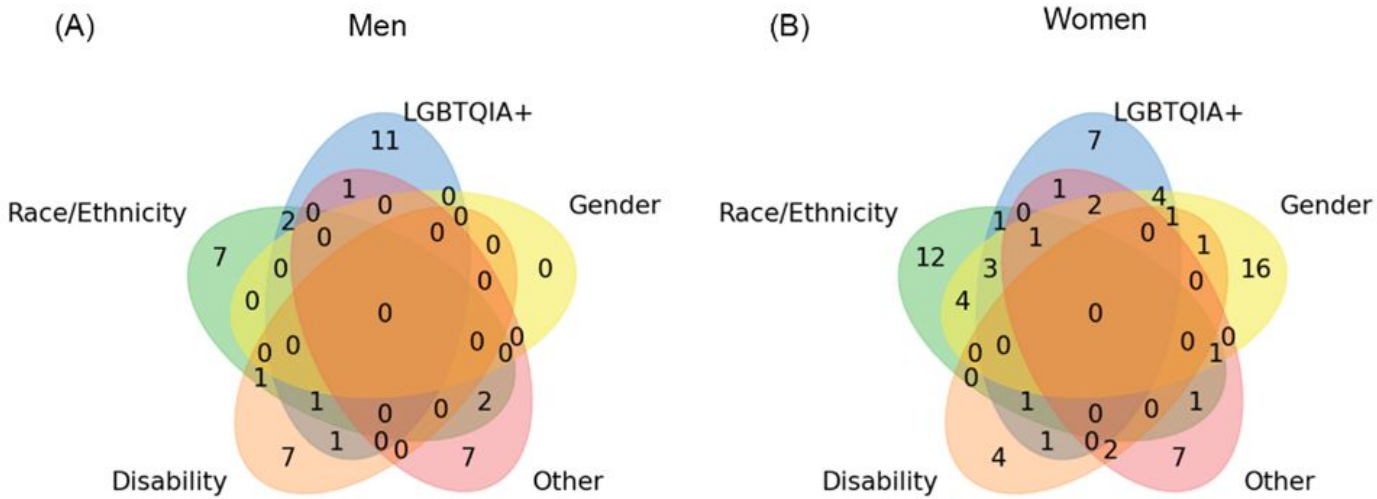
- Pre-COVID, women identifying as being minoritised had the lowest belongingness of all students, this increased when teaching moved online, and dropped again after returning to campus.
- Non-minoritised women had a very similar belongingness to non-minoritised men, although they have slightly diverged recently.
- Most recently, a dramatic and statistically significant decrease in the belongingness of minoritised men.



UCD College of Science – January 2022

- 378 students completed the survey; 355 valid responses. Population ~2,000; response rate ~19%
- 54% identified as women (W), 43% as men (M), 3% as non-binary (NB) and ~1% preferred to not disclose (ND).
- 34% of students identified as minoritised and 64% as non-minoritised
- Belongingness scores can range from -78 to 132, with a midpoint of 27. The mean for all students is 40.9.





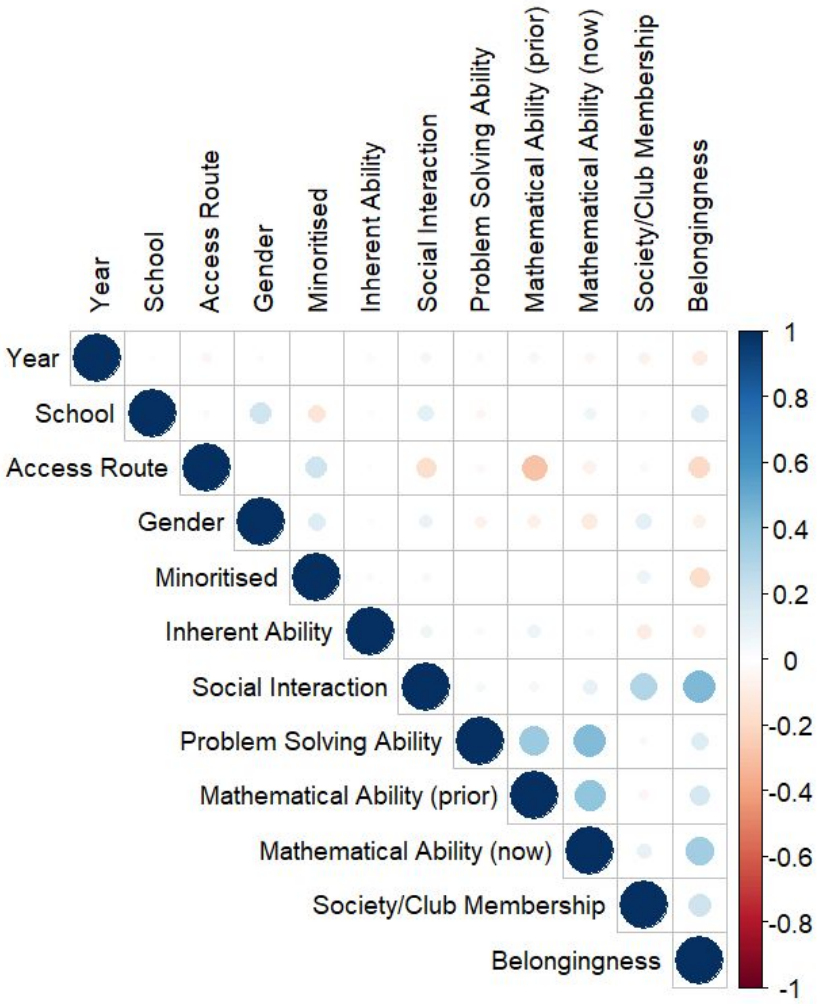
- Men: 29% identified as minoritised, none due to their gender.
- Women: 37% identified as minoritised.
  - 46% identified as minoritised due to their gender and 23% stated that the only reason they were minoritised was their gender.
- ‘Other’ reasons included being a mature student, being religious and socio-economic background.

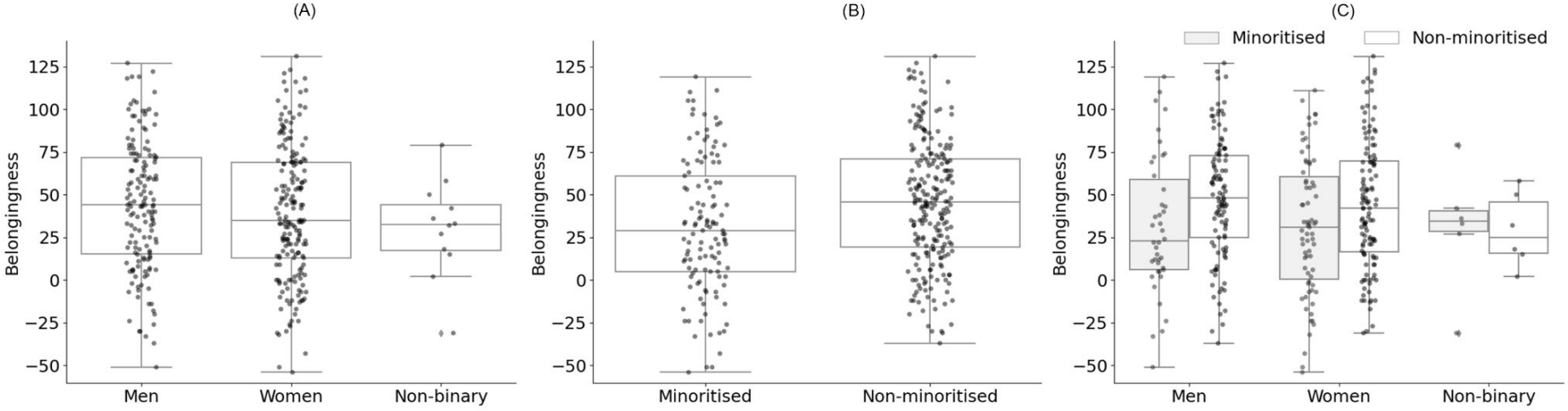
Most positively correlated with belongingness:

- social interaction
- mathematical ability (now)
- society/club membership
- mathematical ability (prior)

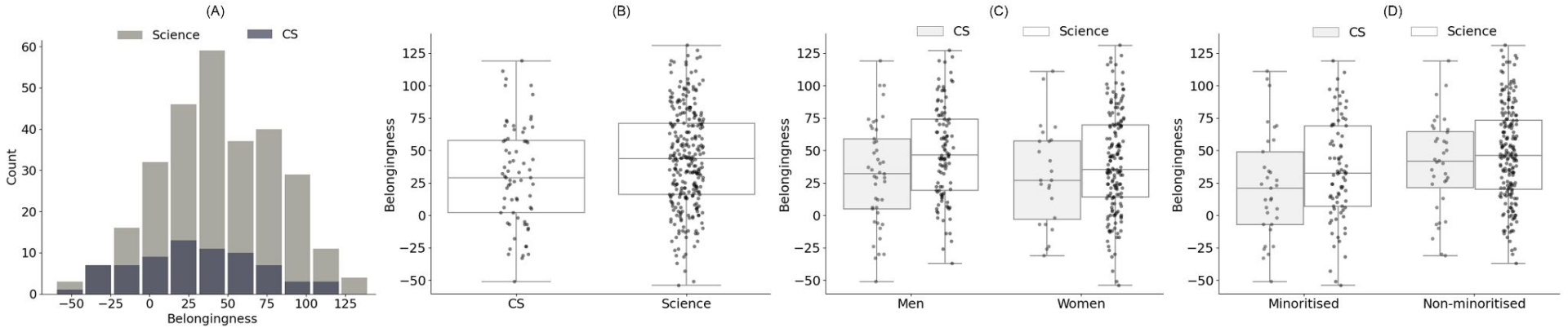
Most negatively correlated with belongingness:

- access route
- minoritisation

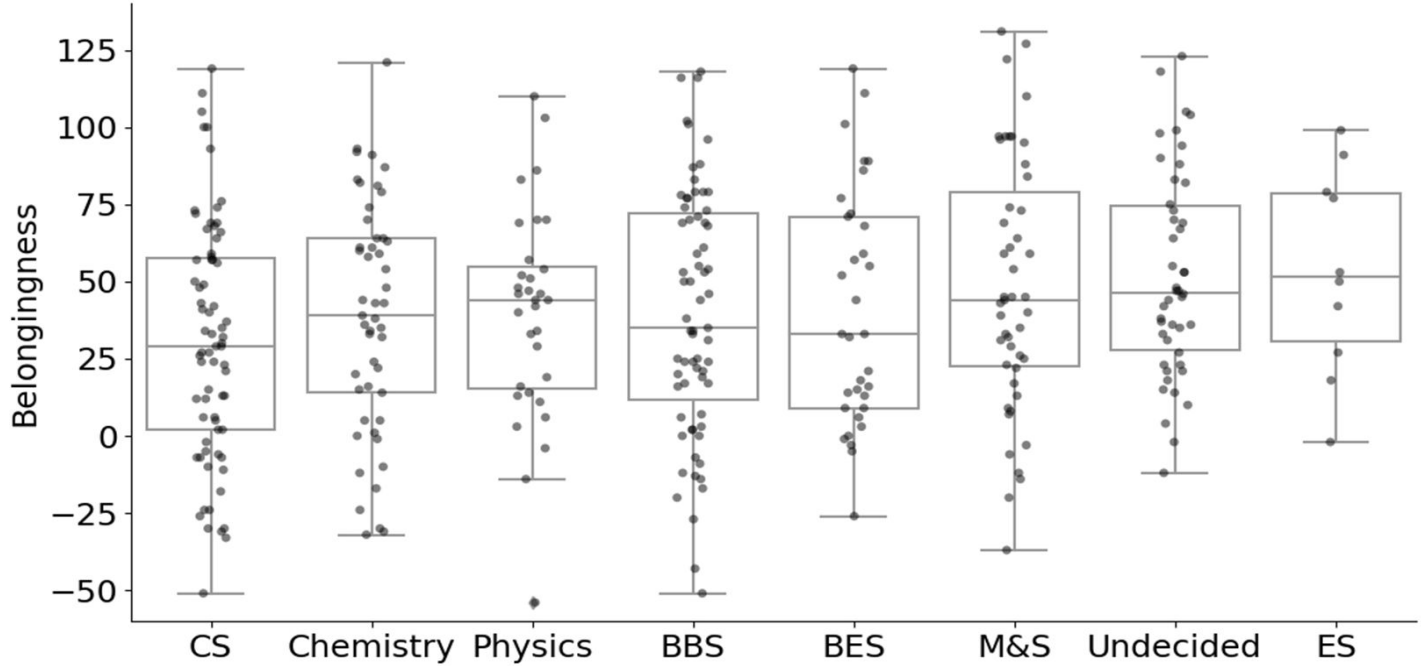




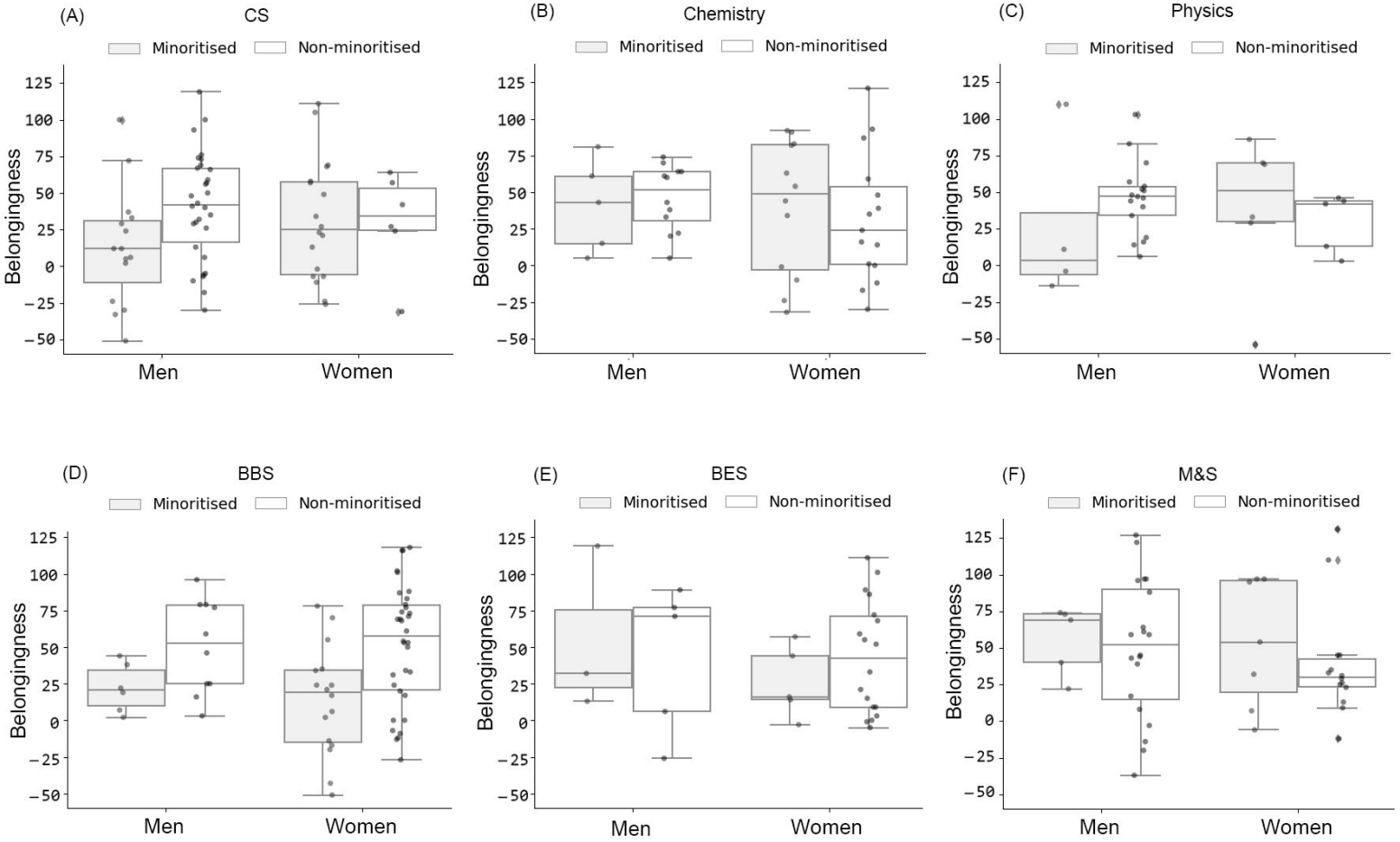
- There is no statistically significant difference in the sense of belonging between students who self-identify as men, women, or non-binary (one-way ANOVA $F(2,350) = 1.036$, $p = 0.356$).
- Minoritised students have a statistically significantly lower belongingness ($t(227.05) = -3.22$, $p < 0.001$).
- Minoritised men and women have a statistically significantly lower mean belonging compared to non-minoritsed men and women ($t(68.113) = -2.334$, $p = 0.022$ and $t(140.44) = -2.186$, $p = 0.030$, respectively).
- Non-minoritised women have a very similar mean belongingness to non-minoritised men.



- (A) shows a histogram of the distributions of belongingness scores for computer science students compared to other science students. Both distributions are fairly normal (slightly left-skewed).
- (B) Computer Science students have a lower belongingness ($p = 0.01$)
- (C) Men in computer science have a lower belongingness ($p = 0.01$) than men in science.
- Although there is a lower mean belongingness of women in computer science, this is not statistically significant.
- (D) Although the belongingness of minoritised and non-minoritised computer science students is also lower this difference is also not statistically significant.



- A one-way ANOVA revealed that there was not a statistically significant difference in belongingness between students in the seven schools or undecided students ($F(7, 347) = 1.759$, $p = 0.094$.
- CS has the lowest mean belongingness score 30.7 (range 30.7-53.4).


(A)
CS
Minoritised
Non-minoritised
Belongingness
125
100
75
50
25
0
−25
−50
Men
Women
(B)
Chemistry
Minoritised
Non-minoritised
Belongingness
125
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75
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−25
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Men
Women
(C)
Physics
Minoritised
Non-minoritised
Belongingness
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Belongingness
125
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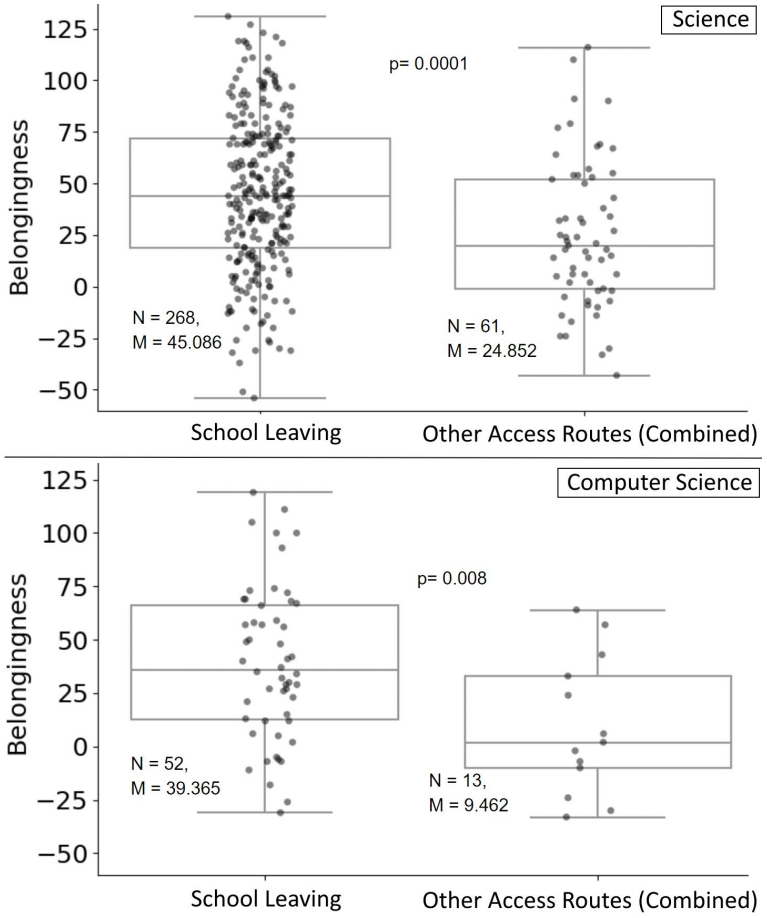
Men
Women

UCD entry pathways

- Results reveal a statistically significant difference (p=0.0001) in SoB between students entering the CoS through the traditional school leaving route and those entering via access routes. Furthermore, within the CS, the SoB of school leaving students was significantly higher than combined access route students (p=0.008).
- UCD access routes:
  - QQI-FET
  - Mature Applicant
  - Higher Education Access Route (HEAR)
  - Disability Access Route to Education (DARE)
  - UCD University Access Courses
  - UCD Open Learning Certificate



Lessons Learned

- Think and plan ahead!
  - These things take time
- Luck helps!
  - Having pre-pandemic data when the pandemic struck was 100% not our intention!
- Ethics/IRB
  - Push to get your ethical permission for as long a time as possible
  - Make your first ethics application grand - build-in possibilities for expansion early
  - Make it so that it (hopefully) can be used by future partners and collaborators with minimal surgery for their context
- Biggest problems?
  - Response rate worries!
  - Dealing with humans
    - The team and the collaborators are where these things sink or swim
- Biggest reward?
  - Dealing with (most of the) humans

Future Work

- Explore confidence in Maths ability before entry into university and now, and how this affects SoB, especially for minoritised students and access students
- Compare maths confidence to programming confidence and prior experience
- Explore the belongingness of First Generation Students
- Create a set of recommendations to increase SoB, with a focus on minoritised students
- Other ideas?

Publications

Runa, S., Antoniadi, A., Becker, B., & Mooney, C. (2023). Student Sense of Belonging: The Role of Gender Identity and Minoritisation in Computing and Other Sciences. In Proceedings of the 25th Australasian Computing Education Conference (pp. 87–96).

Runa, S., Becker, B., & Mooney, C. (2022). Variations in Sense of Belonging in Undergraduate Computing Students Through the COVID-19 Pandemic. In Proceedings of the 2022 Conference on United Kingdom & Ireland Computing Education Research (pp. 1–1).

Mooney, C., & Becker, B. (2021). Investigating the Impact of the COVID-19 Pandemic on Computing Students' Sense of Belonging. In SIGCSE '21: Proceedings of the 52nd ACM Technical Symposium on Computer Science Education (pp. 612–618).

Mooney, C., & Becker, B. (2020). Sense of belonging: The intersectionality of self-identified minority status and gender in undergraduate computer science students. In United Kingdom & Ireland Computing Education Research conference. (pp. 24–30).

Mooney, C., Antoniadi, A., Karvelas, I., Salmon, L., & Becker, B. (2020). Exploring sense of belonging in computer science students. In Proceedings of the 2020 ACM Conference on Innovation and Technology in Computer Science Education (pp. 563–563).

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Questions

Thank you, any questions?

If you would like to follow up with us we would love to hear from you:

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