Associations between Secondary School Students' Spatial Skills and Teacher Perceptions of CS Engagement and Aptitude

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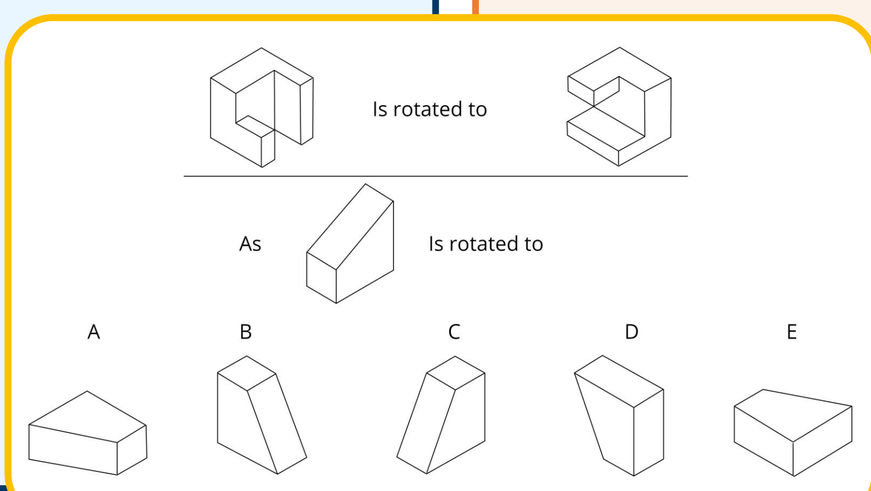
Background

Spatial skills are cognitive skills associated with understanding space and spatial concepts, which are linked to STEM (and CS) success.

- There are many spatial subskills, such as spatial orientation and mental transformation
- Spatial visualisation, and particularly **mental rotation**, has been associated with success in several STEM areas, including CS.
- Within CS, spatial skills have been associated with expression evaluation [7], programming problem solving activities [8], coding questions in exams [2, 4, 6] and standardised assessments [1, 5].
- However, almost all this work has been carried out only at **university** level [3].



Sample item from the revised PSVT:R, the test used in this study [10]

Method

A spatial skills test and a teacher survey was issued in class in six secondary schools in S2 CS classes, resulting in 118 data points.

- S2 is year 2 of secondary school in Scotland. CS is compulsory.
- The students completed the PSVT:R spatial visualisation test and a short interest survey, which included a gender field [9].
- For each student, teachers indicated their perception of the student's **aptitude for** and **engagement in** CS with 5-point Likert scales.
- Teachers were **not** aware of the students' spatial skills scores.

Results

There was very little distinction between teachers' perceptions of students' engagement and aptitude.

- The same value was reported for **66%** of the students .
- A difference of one Likert point for 18% and two or more points for 16%.
- The measures were **not different** when compared with a t-test.

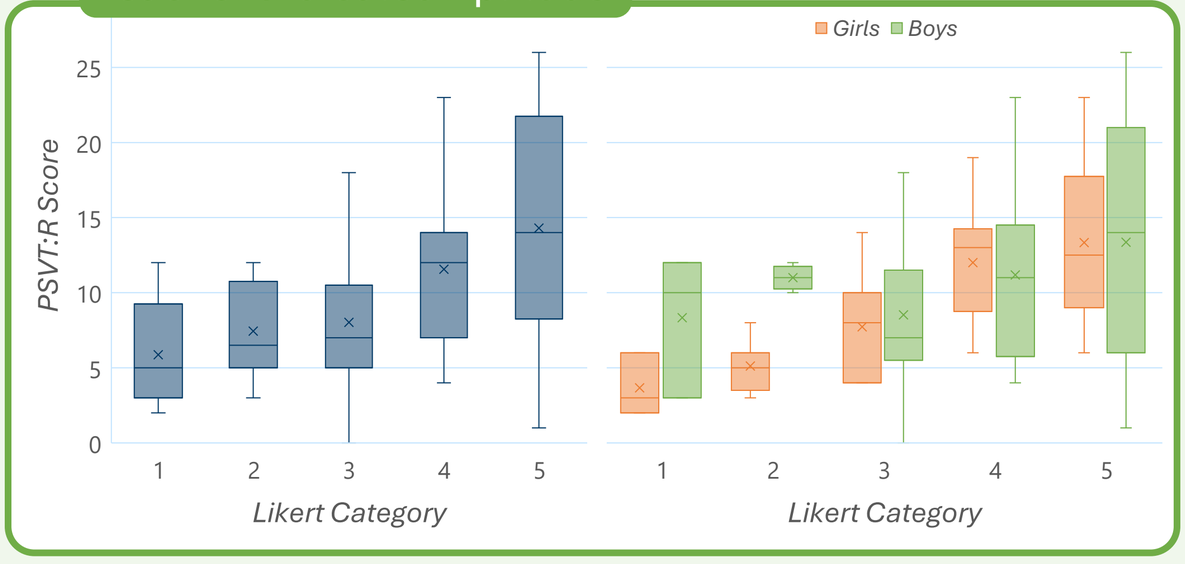
This suggests that these teachers do not make strong distinctions between engagement and aptitude (or perhaps were not effectively equipped to distinguish them in this context)

ANOVAs were conducted to determine if there were significant differences between students' spatial skills based on their teacher-indicated aptitude and engagement.

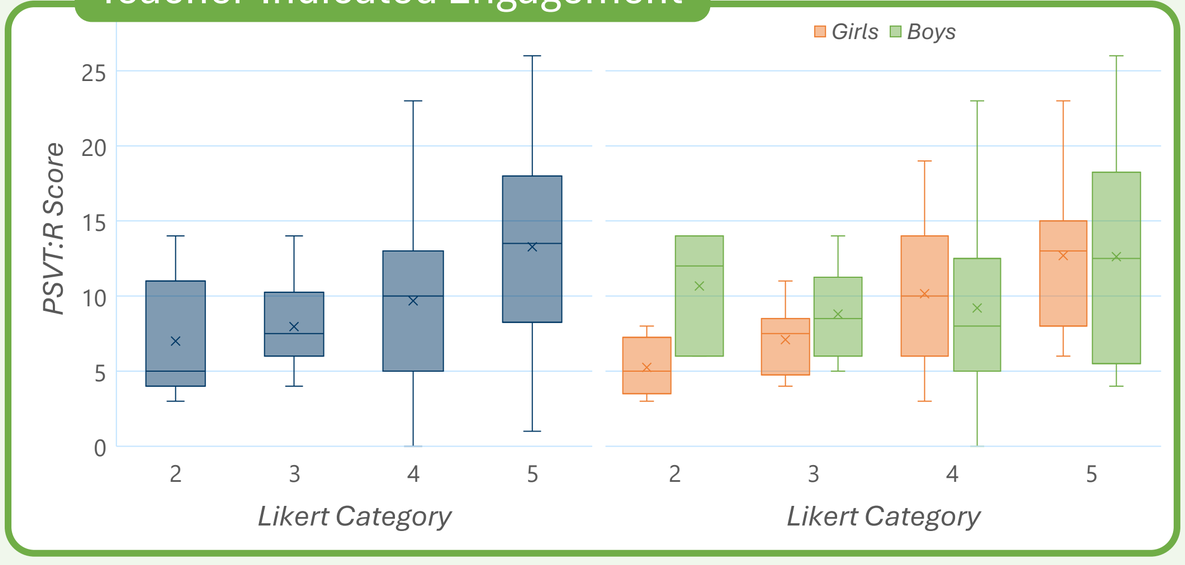
- Generally, students with **higher spatial skills** are perceived by teachers to be **more engaged** and have **higher aptitude** than students with lower spatial skills.
- However, when split by gender, ANOVAs indicated significant differences **only in girls**, and the differences went away for boys.

This suggests that spatial skills only make a difference for teachers' perceptions of aptitude and engagement for girls.

Teacher-Indicated Aptitude



Teacher-Indicated Engagement



ANOVA Results

	Aptitude		Engagement	
	F-stat	*p*-value	F-stat	*p*-value
All	8.69	0.000	6.79	0.000
Girls	9.28	0.000	4.70	0.000
Boys	1.29	0.286	1.50	0.225

Discussion

This work leaves us with many questions on which I would welcome community input:

- How **reliable** are teacher estimations of aptitude and engagement? What do they really take these to mean? What effects might these have on a class?
- **Why** would spatial skills be a factor in teachers' perceptions of aptitude and engagement?
- Why would there be **differences** in the effect of **spatial skills** on teachers' perceptions of aptitude and engagement between girls and boys?
- What are the implications for how students may be treated if they have **poor spatial skills**, particularly if there are gender differences in teachers' perceptions of the students' abilities?
- We know that spatial skills make some difference in higher education, so we should continue to investigate their impact on outcomes in secondary school.

Future Work

This is very **preliminary** work! There are many ways to improve and expand upon it:

- Would the results be the same if we used more concrete measures of aptitude, such as **programming tests** or **exercises**?
- We should investigate with similar studies which use **more robust measures** than single Likerts for aptitude and engagement.
- We should incorporate **student perspectives** and **self-assessments**.
- We should explore spatial outcomes with respect to **senses of belonging** and **self-belief** in CS, alongside richer **teacher reflections**.
- We should conduct **qualitative** work exploring students' approaches to learning and solving problems in CS.
- We should explore more factors than just gender, such **as socio-economic status** and **subject choice**.
- What areas of secondary school CS do spatial skills make a difference in?

References

[1] Ryan Bockmon, Stephen Cooper, Jonathan Gratch, Jian Zhang, and Mohsen Dorodchi. 2020. Can Students' Spatial Skills Predict Their Programming Abilities? ITiCSE 2020, Trondheim, Norway. https://doi.org/10.1145/3341525.3387380
[2] Ryan Bockmon, Stephen Cooper, William Koperski, Jonathan Gratch, Sheryl Sorby, and Mohsen Dorodchi. 2020. A CS1 Spatial Skills Intervention and the Impact on Introductory Programming Abilities. SIGCSE 2020. Portland, OR, USA. https://doi.org/10.1145/3328778.3366829
[3] Stephen Cooper, Karen Wang, Maya Israni, and Sheryl Sorby. 2015. Spatial Skills Training in Introductory Computing. ICER 2015. Omaha, NE, USA. https://doi.org/10.1145/2787622.2787728
[4] Anna Ly, Jack Parkinson, Quintin Cutts, Michael Liut, and Andrew Petersen. 2021. Spatial Skills and Demographic Factors in CS1. Koli Calling, 2021. Joensuu, Finland. https://doi.org/10.1145/3488042.3488049
[5] Miranda C. Parker, Amber Solomon, Brianna Pritchett, David A. Illingworth, Lauren E. Marguilieux, and Mark Guzdial. 2018. Socioeconomic Status and Computer Science Achievement: Spatial Ability as a Mediating Variable in a Novel Model of Understanding. ICER 2018. Espoo, Finland. https://doi.org/10.1145/3230977.3230987
[6] Jack Parkinson and Quintin Cutts. 2020. The Effect of a Spatial Skills Training Course in Introductory Computing. ITiCSE 2020. Trondheim, Norway. https://doi.org/10.1145/3341525.3387413
[7] Jack Parkinson, Quintin Cutts, and Steve Draper. 2020. Relating Spatial Skills and Expression Evaluation. UKICER 2020. Glasgow, United Kingdom. https://doi.org/10.1145/3416465.3416473
[8] Jack Parkinson and Quintin Cutts. 2023. Understanding Spatial Skills and Encoding Strategies in Student Problem Solving Activities. ICER 2023. Chicago, US. https://doi.org/10.1145/3568813.3600134
[9] Katta Spiel, Oliver L. Haimson, and Danielle Lottridge. 2019. How to do better with gender on surveys: a guide for HCI researchers. Interactions 26, 4 (Jun 2019). https://doi.org/10.1145/3338283
[10] So Yoon Yoon. 2011. Psychometric properties of the Revised Purdue Spatial Visualization Tests: Visualization of Rotations (the Revised PSVT:R). Ph. D. Dissertation. Purdue University.

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