THE TIMES THE SUNDAY TIMES GOOD UNIVERSITY GUIDE 2020 INSTITUTE OF TECHNOLOGY OF THE YEAR

AIT Research

Investigating the role of visualisation in complex problem-solving across expertise in engineering education

Clodagh Reid[1, Ŧ], Dr Rónán Dunbar[1], Dr Jeffrey Buckley [1, 2], Prof Brian Bowe [3].
[1] Athlone Institute of Technology, Co. Westmeath, [2] KTH Royal Institute of Technology, Stockholm, Sweden.
[3] Technological University for Dublin, Co. Dublin.
c.reid@research.ait.ie

Introduction

- Spatial ability is proposed to play an important role in problem solving and may contribute to supporting engineering students in solving complex problems [1, 2].
- Hambrick, et al. [1], in the context of geology, determined individuals with lower levels of expertise and high levels of spatial ability can perform to a similar standard to those with high levels of expertise. To date, a study of this nature had not been carried out in engineering education.

Through this research the role of spatial visualisation, a cognitive ability related to success in STEM [3, 4], and expertise are examined in relation to the performance of engineering students on a complex problem.

Method

Sample

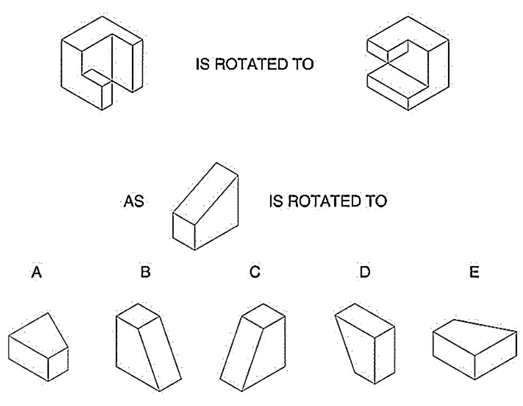
Undergraduate 1st (n = 63) and 3rd (n = 52) year engineering students invited to participate in this study.

Session One

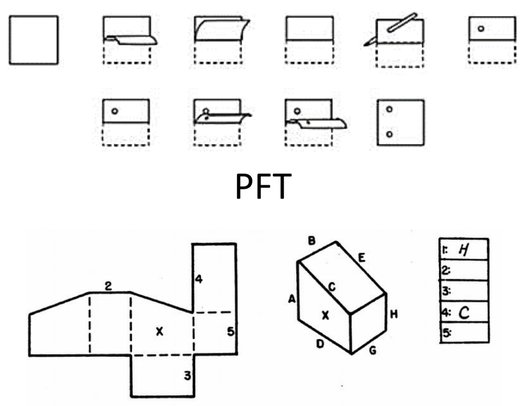
- The 3- and 4-disc models of The Tower of Hanoi (TOH) adminsitered.
- Audio and video recording equipment used throughout the problem solving session to monitor performance.
- 9-point Likert-type item administered when problem completed to determine the mental effort, difficulty, stress and concentration experienced when solving the problem.

Session Two

Purdue spatial visualisation test and rotations (PSVT:R) [5], surface development test (SDT) and paper folding test (PFT) administered [6]. The order of administration was randomised to account for order bias.



PSVT:R



PFT

SDT

Results

- No significant difference between 1st (M = 9.28, SD = 4.21) and 3rd year (M = 9.93, SD = 3.42) performance on the 3-disc TOH conditions; t(73) = -0.69, p = 0.49.
- No significant difference between 1st (M = 30.09, SD = 19.16) and 3rd year (M = 30.21, SD = 17.63) performance on the 4-disc TOH conditions; t(73) = -0.03, p = 0.98.

Correlations

		PSVT Score	SDT Score	PFT Score	3-Disc Moves
SDT Score	Pearson Correlation	.590**			
	Sig. (2-tailed)	0.000	–		
PFT Score	Pearson Correlation	.478**	.599**		
	Sig. (2-tailed)	0.000	0.000	–	
3-Disc Moves	Pearson Correlation	-0.116	-0.064	-0.052	
	Sig. (2-tailed)	0.320	0.588	0.655	–
4-Disc Moves	Pearson Correlation	0.022	-0.092	-.240*	0.215
	Sig. (2-tailed)	0.853	0.432	0.038	0.064

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Conclusions

Key Findings

1. **Engagement in engineering education did not lead to the development of complex problem-solving skills for the sample included in this study.**
2. **Spatial visualisation did not have a significant correlation to performance on the complex problems included in this study.**

Contribution

As, to the best of our knowledge, no previous study has investigated the relationship between spatial visualisation and problem solving in the context of engineering across levels of expertise. This research contributes towards understanding this relationship. Future work will investigate this relationship during a discipline-specific task.

Dissemination

This study has been developed into a full peer-reviewed paper and accepted to the PATT38 international conference.

References

[1] Hambrick, D. Z., Libarkin, J. C., Petcovic, H. L., Baker, K. M., Elkins, J., Callahan, C. N., ... & LaDue, N. D. (2012). A test of the circumvention-of-limits hypothesis in scientific problem solving: The case of geological bedrock mapping. *Journal of Experimental Psychology: General*, *141*(3), 397.
[2] Ramey, K. E., & Uttal, D. H. (2017). Making sense of space: Distributed spatial sensemaking in a middle school summer engineering camp. *Journal of the Learning Sciences*, 26(2), 277-319.
[3] Kell, H. J., & Lubinski, D. (2013). Spatial ability: A neglected talent in educational and occupational settings. *Roeper Review*, 35(4), 219-230.
[4] Wai, J., Lubinski, D., & Benbow, C. P. (2009). Spatial ability for STEM domains: Aligning over 50 years of cumulative psychological knowledge solidifies its importance. *Journal of educational Psychology*, 101(4), 817.
[5] Bodner, G. M., & Guay, R. B. (1997). The Purdue visualization of rotations test. *The Chemical Educator*, 2(4), 1-17.
[6] Ekstrom, R. B., Dermen, D., & Harman, H. H. (1976). Manual for kit of factor-referenced cognitive tests (Vol. 102). Princeton, NJ: *Educational testing service*.

TERG TECHNOLOGY EDUCATION RESEARCH GROUP

This work is funded by the President Doctoral Scholarship at Athlone Institute of Technology.

c.reid@research.ait.ie
@Clodagh_Reid1