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Visualizing Success: Investigating the Relationship between Ability and Self-Efficacy in the Domain of Visual Processing

Jason Power Mr
University of Limerick, jason.power@ul.ie

Jeffrey Buckley Mr
University of Limerick, jeffrey.buckley@ul.ie

Niall Seery Dr
University of Limerick, niall.seery@ul.ie

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Visualizing Success: Investigating the Relationship between Ability and Self-Efficacy in the Domain of Visual Processing

Jason Power, Jeffrey Buckley and Niall Seery
Department of Design and Manufacturing Technology
University of Limerick

Abstract

The purpose of this study is to investigate the spatial reasoning capacities and related self-efficacy beliefs of student teachers. In recent years self-efficacy has been a focal point for those investigating various modes of determinism. The relationship between an individual's perceptions of their ability to succeed within spatial reasoning tasks is examined in conjunction with their spatial reasoning ability. In this study three tests of spatial ability were administered to align with three unique spatial factors associated with mental rotation. These include Spatial Relations, Speeded Rotation and Spatial Orientation. Self-efficacy within the spatial domain is measured using an adapted Academic Self-Efficacy scale.

Introduction

Bandura's (1986) social cognitive theory proposed that individuals perform or behave in a manner that is governed primarily by internal mechanisms such as self-reflection, cognition and vicariousness. When considered in terms of self-efficacy these factors are said to be task orientated rather than general environmental factors. Bandura (1997) suggests that what an individual believes, rather than what is objectively true, is a stronger indicator of performance, motivation and well-being. If an individual does not believe that their actions can have a meaningful and positive result they have no incentive to attempt said action. It is for these reasons that an individual's belief can often be a better indicator of future performance than actual ability in a given field. Self-efficacy can affect the manner in which an individual negotiates problems, both in cognitive constructions of solutions and analyses of requirements, and in emotional response (Bandura 1997). Pajares and Miller (1995) examined the performance of third level students in mathematical problem solving and found that self-efficacy was a more accurate predictor than domain specific self-concepts, perceived usefulness, gender or prior mathematical experience. Pajares (1996) noted that self-efficacy as a predictor increased in correlation with the specificity and equivalence to a skill.

The identification of self-efficacy as being such a critical component in task performance within specific disciplines, coupled with the identification of high levels of spatial ability correlating with success in a number of engineering and graphics related disciplines (Harle &

Towns, 2010; Lubinski, 2010; Maeda & Yoon, 2012; Sorby, 2009), suggests that viewing spatial ability through the lens of self-efficacy could uncover a new research avenue in spatial cognitive development. The studies which have identified this correlation have typically adopted tests requiring mental rotations such as the Purdue Spatial Visualization Test: Visualization of Rotations (PSVT:R) (Guay, 1977). However, significant literature suggests additional spatial factors pertinent to mental rotations and the debate concerning the existence of these additional factors persists (Seery, Buckley, & Delahunty, 2015). For example, Hegarty and Waller (2004) present empirical evidence suggestive that perspective taking abilities are dissociable from mental rotation abilities. It is posited that their shared variance is the reason for previous studies identifying them as a common factor. The results of this and various other studies have identified a multiplicity of unique spatial factors. Carroll's (1993) meta-analysis of human cognitive abilities presents substantial empirical data to support this view. As such, it is important that studies concerning areas of spatial ability such as mental rotations take cognizance of this concept and employ a variety of measures to ensure an accurate representation of ability is generated.

Method

The study cohort consisted of a group of 3rd year undergraduate students in Initial Technology Teacher Education (ITTE) (n=90) of which 11 were female and 79 were male. The mean age of the participants was 21.41 with a standard deviation of 2.90. They were selected based on their inclusivity within a Design and Communication Graphics module as this was the student's 4th graphical education module and all such modules have an inherent focus on the development of spatial reasoning capacities.

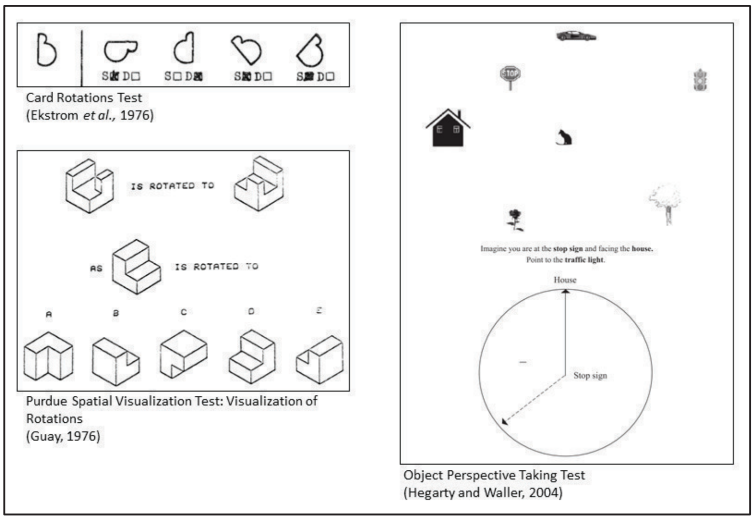

Figure 1: Examples of the spatial ability tests adopted within this study

Initially, each student completed a Sources of Self-efficacy in Spatial Ability scale (Appendix A) which was adapted from Sources of Self-efficacy in mathematics (Usher and Pajares 2009). Following their engagement with the self-efficacy questionnaire, each participant completed 3 spatial ability tests selected to align with 3 unique spatial factors pertinent to mental rotations (Figure 1). The participants were divided into 6 different groups and the tests were administered in a unique order to each to control for order bias. The PSVT:R (Spatial Relations) (Guay, 1977), Card Rotations Test (Speeded Rotations) (Ekstrom, French, Harman, & Derman, 1976) and the Object Perspective Test (Spatial Orientation) (Hegarty & Waller, 2004) were administered. Due to a lack of access to the Object Perspective Taking Test, 16 questions were designed under the exact conditions as the original test, using the exact same array of visual images. These factors were selected for inclusion in this study to align with the previously discussed correlational studies which typically included tests of mental rotation. A primer was delivered verbally which described what was meant by a spatial reasoning problem to ensure clarity of this concept.

Results

A descriptive statistical analysis was initially conducted on the average results from the three spatial ability tests which revealed three outliers within the data sample (See Figure 2). The results from these participants were removed from the subsequent correlational analysis.

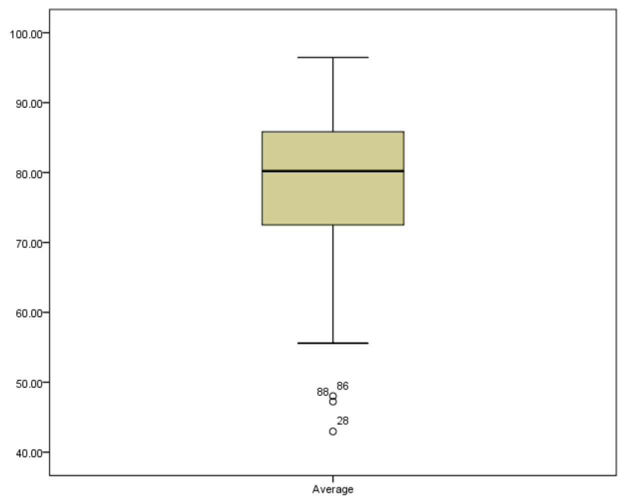

Figure 2: Boxplot illustrating statistical outliers within the data sample

The results from each of the variables within the study were compared by Pearson's correlation coefficient (See Table 1). The reliability of each of the spatial ability tests was measured using Cronbach's alpha. The alpha coefficient for the PSVT:R was 0.726, for the Object Perspective Taking Test it was 0.865 and for the Card Rotations Test it was 0.978.

Table 1: Correlation Matrix for Study Variables

	PSVT	Object Perspective Taking Test	Card Rotations Test	Mastery Experience	Vicarious Experience	Social Persuasions	Psyological State
PSVT	1						
Object Perspective Taking Test	.228*	1					
Card Rotations Test	.263**	.230**	1				
Mastery Experience	.249**	.191*	.162*	1			
Vicarious Experience	.086*	-.011*	-.036*	.403***	1		
Social Persuasions	.120*	.092*	.088*	.535***	.252**	1	
Psyological State	-.014*	-.207*	-.182*	-.562***	-.399***	-.293***	1

Notes: *. Correlation is non-significant; **. Correlation is significant at the 0.05 level (2-tailed); ***. Correlation is significant at the 0.01 level (2-tailed).

Discussion

Although each of the 3 tests used are considered tests of spatial ability, it is posited that each measure targets a unique spatial factor pertinent to mental rotations. This is evident from multiple theoretical and empirical perspectives (e.g. Carroll, 1993; Hegarty & Waller, 2004) and is supported by the significant but small correlations with *r* values ranging from .228 to.268 (n=87, $p<0.05$) (See Table 1). As shown in Table 1, Physiological State negatively and significantly correlates with each additional posited source with *r* values ranging from -.293 to -.562 (n=87, $p<0.001$). As supported by the literature, Mastery was the only source that held any predictive value (Parker et al. 2014, Usher and Pajares 2009, Pajares 2007) however this was limited to performance in the PSVT:R (r=0.249, n=87, $p=0.014$). This highlights concerns relating to variance across domains. Often what researchers consider a sole domain is considerably less homologous than the original conception. This echoes the warnings of Bandura (2006) who cautions that researchers must be cognizant of the domain when examining self-efficacy. This is reflected in this study as pertinent research often suggests the non-existence of some spatial factors relative to mental rotations however the results of this study suggest that the three contentious factors may be unique. The significance in these results for engineering and graphics educators stems from the previously discussed correlation between spatial ability and success in the domain. One important finding is that high levels of self-efficacy pertinent to Mastery of spatial ability correlated with success in the PSVT:R. This suggests that fostering the belief within students that their levels of spatial ability can be developed could be a significant pedagogical approach to developing these skills and thus increasing capacities within STEM education. In addition to this, the distinction between 3 types of mental rotation offer additional lenses to continue research into this correlation as tests associated with mental rotations are often utilized in the studies which uncovered this relationship.

Reference List

Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs NJ: Prentice Hall

Bandura, A. (1997). *Self Efficacy: The Exercise of Control*. New York: Freeman.

Bandura, A. (2006). Guide for Constructing Self-Efficacy Scales. In F. Pajares and T. Urdan (Eds.), *Self-Efficacy Beliefs of Adolescents* (307–337). North Carolina: Information Age Publishing.

Carroll, J. (1993). *Human Cognitive Abilities: A Survey of Factor-Analytic Studies*. New York: Cambridge University Press.

Ekstrom, R., French, J., Harman, H., & Derman, D. (1976). *Kit of Factor-Referenced Cognitive Tests*. Princeton, New Jersey: Educational Testing Service.

Guay, R. (1977). *Purdue Spatial Visualization Test: Rotations*. West Lafayette, Indianna: Purdue Research Foundation.

Harle, M., & Towns, M. (2010). A Review of Spatial Ability Literature, Its Connection to Chemistry, and Implications for Instruction. *Journal of Chemical Education*, *88*(3), 351–360.

Hegarty, M., & Waller, D. (2004). A Dissociation Between Mental Rotation and Perspective-Taking Spatial Ability. *Intelligence*, *32*(2), 175–191.

Kozhevnikov, M., & Hegarty, M. (2001). A Dissociation Between Object Manipulation Spatial Ability and Spatial Orientation Ability. *Memory & Cognition*, *29*(5), 745–756.

Lubinski, D. (2010). Spatial ability and STEM: A Sleeping Giant for Talent Identification and Development. *Personality and Individual Differences*, *49*(4), 344–351.

Maeda, Y., & Yoon, S. Y. (2012). A Meta-Analysis on Gender Differences in Mental Rotation Ability Measured by the Purdue Spatial Visualization Tests: Visualization of Rotations (PSVT:R). *Educational Psychology Review*, *25*(1), 69–94.

Schneider, J., & McGrew, K. (2012). The Cattell-Horn-Carroll Model of Intelligence. In D. Flanagan & P. Harrison (Eds.), *Contemporary Intellectual Assessment: Theories, Tests, and Issues* (3rd ed., pp. 99–144). New York: Guilford Press.

Seery, N., Buckley, J., & Delahunty, T. (2015). Developing a Spatial Ability Framework to Support Spatial Ability Research in Engineering Education. In *The 6th Research in Engineering Education Symposium*. Dublin, Ireland: Dublin Institute of Technology.

Sorby, S. (2009). Educational Research in Developing 3-D Spatial Skills for Engineering Students. *International Journal of Science Education*, *31*(3), 459–480.

Wai, J., Lubinski, D., & Benbow, C. (2009). Spatial Ability for STEM Domains: Aligning over 50 years of Cumulative Psychological Knowledge Solidifies its Importance. *Journal of Educational Psychology*, *101*(4), 817–835.

Appendix A – Sources of Self-efficacy in Spatial Ability scale

Item	Statement	Category
1	I score highly on spatial ability tests (ME-1)	Mastery Experience
2	I have always been successful with spatial reasoning tasks (ME-3)	
3	Even when I try very hard, I do poorly in spatial reasoning tasks (ME-6)	
4	I have gotten good grades in previous spatial ability related modules (ME-8)	
5	I do well on spatial ability related assignments (ME-9)	
6	I do well on even the most difficult spatial ability assessments (ME-12)	
7	Seeing others do well in spatial ability related activities pushes me to do better (VA-4)	Vicarious Experience
8	When I see how my TA solves a problem, I can picture myself solving the problem in the same way (VA-6)	
9	Seeing others do better than me in spatial ability related tasks pushes me to do better (VP-1)	
10	When I see how another student solves a spatial reasoning problem, I can see myself solving the problem in the same way (VP-9)	
11	I imagine myself working through challenging spatial reasoning problems successfully (VS-4)	
12	I compete with myself in spatial reasoning exercises (VS-5)	
13	My TAs have told me that I am good at spatial reasoning tasks (P-4)	Social Persuasions
14	People have told me that I have a talent for spatial reasoning tasks (P-5)	
15	Adults in my family have told me that I have a talent for spatial reasoning tasks (P-7)	
16	I have been praised for my ability in spatial reasoning tasks (P-13)	
17	Other students have told me that I'm good at spatial ability related activities (P-14)	
18	My classmates like to work with me on spatial ability related activites because they think I'm good at it (P-16)	
19	Working on spatial reasoning tasks makes feel stressed and nervous (PH-2)	Physiologic al State
20	Doing spatial ability related work takes all of my energy (PH-3)	
21	I start to feel stressed-out as soon as I begin spatial ability related work (PH-5)	
22	My mind goes blank and I am unable to think clearly when doing spatial ability related work (PH-7)	
23	I get depressed when I think about spatial ability related work (PH-9)	
24	My whole body becomes tense when I have to do spatial ability related work (PH-12)	
25	It's important to me that other students in my class think I am good at spatial ability related tasks.	Personal Performance -Approach Goal Orientation
26	One of my goals is to show others that I'm good at spatial ability related tasks.	
27	One of my goals is to show others that spatial ability related tasks are easy for me.	
28	One of my goals is to look better in comparison to the other students in my class.	

Notes: All items were scored on a 7-point Likert scale ranging from 1 = "Not at all true of me" to 7 = "Very true of me".