Improving Student Spatial Skills: Using Life Experiences and Motivational Factors to Inform Instructional Interventions

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Spatial thinking refers to the ability to create and hold an object in the mind's eye and manipulate that object via sectional cuts, three dimensional rotations, and other mental operations. Prior research suggests that the degree to which students differ in their development of spatial skills affects their performance on instructional tasks that require spatial visualization. This study builds on prior efforts to identify how individuals' beliefs and experiences influence spatial skills. A revised instrument was developed and allows for the analysis of the interaction between early life experiences, motivation, and spatial skills. Based on a factor analysis, these life experiences are grouped into factors that are then analyzed for correlation with spatial skills. Results indicate a positive correlation between early life experiences in designing and building things and high spatial skills. Results also indicate those that believe knowledge is fixed tend to have lower spatial skills. This effect is mediated by individuals' self-efficacy beliefs.

Background

The process of holding the image of an object in our mind's eye and manipulating it is an important skill that enables problem solving in a variety of domains. Referred to as spatial reasoning, visuo-spatial thinking, spatial cognition, and spatial intelligence among other terms, this skill is an accumulation of other sub-skills. At a minimum there are the distinct abilities of spatial relations and spatial visualization. Spatial relation refers to the ability to imagine the rotation of objects as intact bodies and also how one's own body is oriented relative to an object. Spatial visualization refers to the ability to imagine how objects are modified by folding or unfolding.[1] While there are distinct skills under the broader category of spatial cognition, an individual that is a high achiever in one is often a high achiever in the other. The key importance of the distinction is in how it informs instruction regarding spatial cognition.

An individual's "spatial ability not only plays a unique role in assimilating and utilizing preexisting knowledge, but also plays a unique role in developing new knowledge."[2] A key factor in spatial reasoning is the mental manipulation of objects or, more strictly, the manipulation of the mental image of an object that has been viewed or imagined. During this mental manipulation people adjust the iconic image in their mind as the external object changes. The neural control of the image is the primary factor separating high and low spatially skilled individuals. That is to say, the ability to clearly form a mental representation of a three-dimensional external object and to perform actions on the image is the crux of what defines a person's spatial ability.[3] Among the factors impacting an individual's spatial skills are the ability to think abstractly and the ability to construct an iconic representation of an object. The level of ability varies based on the degree to which the individual can describe the object and manipulate it in space.[4]

As important as spatial skills are, many students reach the college level without highly developed spatial skills. Even among those entering STEM disciplines, many college students lack the ability necessary to understand and accurately interpret diagrams, models, and

architectural and engineering drawings.[5] There is thus a higher likelihood for these students to switch to a major that requires less spatial reasoning or to even drop out of school altogether. These students' poorer performance is not due to a lower intelligence than their peers but rather to a lack of opportunity to develop the skills necessary to imagine and manipulate images.[3] The multi-faceted impact of an individual's spatial reasoning on other cognitive skills, mastery of educational topics, and vocational pursuits, it is therefore critical that a system of teaching and enhancing these skills be developed.

Gender and Other Individual Differences on Spatial Ability

It is a common theme in the literature that males are better than females at spatial visualization tasks.[6] However, there is growing evidence that this is not as clear as once thought and may not be a reliable distinction.[7, 8, 9] There is empirical evidence that environmental factors, such as childhood leisure activities, affect spatial skills and academic performance.[10, 11] There is also evidence that the pervasive stereotype that men perform better spatially than women has a detrimental impact on female students' performance on tests of spatial ability. Individuals, such as female engineering students, at risk of confirming a negative performance stereotype about their group are susceptible to *stereotype threat*; a psychological burden that results in underperformance on stereotyped tasks.[12, 13, 14] These gender differences can be greatly reduced by changing the testing environment, changing testing instructions, and providing general affirmation of their skills to women contesting men.[15, 16, 17, 18, 19, 20]

Assessing Spatial Skills

Several methods of assessing spatial skills exist, but the most common ones are the Differential Aptitude Test: Spatial Relations (DAT:SR), the Mental Cutting Test, the Vandenberg Mental Rotation Test, and the previously mentioned Purdue Spatial Visualization Test-Visualization of Rotations (PSVT:R). The PSVT:R is the most widely used test, but before the target audience and specific construct that is intended to be measured must be considered when selecting a test.[6, 19, 21, 22, 23, 24, 25, 26] While each test measures a slightly different aspect of the broad topic of spatial skills, many of them correlate highly with one another. Since this study calls for a measure of general spatial skills, the authors chose a revised version of the PSVT:R test to assess participants' spatial skills.

Authors' Previous Work

Previous work by the authors indicates that individuals' spatial ability differ by gender, age, and ethnicity.[27] However, differences were not found on variables such as a student's classification (or year in school), early life experiences, and college major. Motivational factors, particularly domain-specific self-efficacy, are positively correlated with individuals' spatial skills scores. This study focuses more closely on the role of these motivational factors and also the impact of life experiences. The instrument that was used in the previous study was modified based on an analysis of the results.

Purpose of the Study

There is an abundance of literature regarding the importance of spatial skills and strategies for improving them.[28, 29, 30, 31, 32] This study approaches the topic from a slightly different angle. In order to design and develop an instructional intervention, the authors first focused on the early life experiences and motivational factors that may play a role in individuals' spatial skills. Items

such as hobbies and other interests and activities were analyzed regarding their correlation with spatial skill. In addition to providing insight into the development of an instructional intervention, the analysis of early life experiences was included in this study as a means to investigate less commonly considered variables that may impact individuals' spatial skills. Demographic variables, particularly gender, are commonly analyzed but the authors wished to investigate the possibility of moderating or intervening variables.

In addition to early life experiences, motivational factors such as perceived instrumentality, self-efficacy beliefs, and epistemic beliefs were analyzed. Perceived instrumentality "represents an individual's belief that performing a specific behavior will lead to a desired outcome."[33] An individual's self-efficacy beliefs are rooted in how confident someone is in their competence with regard to a specific task.[34] An individual's epistemic beliefs refers to what that person believes about the nature of knowledge and skill.[35] For this study in particular, the authors are interested in whether individuals believe that everyone has a fixed amount of a certain trait or ability or whether it is possible to acquire more knowledge and skill through study, practice, and training. All of these components of motivation are well understood but there is little existing research that applies such concepts to the domain of spatial skills.

Hypotheses

This study is guided by three primary hypotheses. The first is that individuals who believe that spatial abilities are fixed will not perform as well as those who believe that spatial ability can grow and improve with practice. This gets at the epistemic beliefs of the participants and how it relates to their performance on the spatial skills test.

The second hypothesis is that these epistemic beliefs will be related to spatial ability via self-efficacy beliefs, such that a growth mindset will positively influence self-efficacy beliefs, which will in turn, influence spatial ability.

The final hypothesis is that there are patterns of early life experiences that people with high spatial ability have in common. This is solely focused on analyzing the participants' background and analyzing whether there are any types of activities or experiences that correlate more greatly with high spatial skills than other activities do.

Methodology

Data Collection

The study sample comes from student participants from two universities, one a large Midwest institution with a diverse student population and the second a large Eastern institution that is well known for its Engineering program. Data were collected in the summer and fall of 2015 with undergraduate students in Engineering and other STEM majors.

The instrument that the students completed was done online and during class time. Identical for all participants, the instrument contained three main sections after the initial demographic section. The first section assessed participants' motivation with a five point Likert scale. There were 15 items in total, five each to measure perceived instrumentality, self-efficacy beliefs, and epistemic beliefs. A sampling of items to measure the aspects of motivation are in Table 1.

Table 1: Sample of items used to measure motivation

Self-Efficacy Beliefs	Compared to other students in my major, I think I am good at spatial reasoning activities.
	I am certain I will perform well on a spatial reasoning skill test.
Perceived Instrumentality	Having high spatial reasoning skills is important for performing well in the classes in my major.
	My ability to perform spatial reasoning tasks is important for me to become the professional that I want to be.
Epistemic Beliefs	A person's intelligence is something fixed and can't change.
	You can learn new things but you can't really change your basic intelligence.

The next section also used a five point Likert scale contained 32 items regarding participants' early life experiences, hobbies, and activities. The instrument for this section was piloted in a previous study [27] and revised for this study. The instrument was modified to include a better variety of options for the participants to indicate that they had participated in. The pilot version only focused on activities already thought to be a part of building up spatial skills. The researchers' concern was that it would lead participants to indicate a higher level of participation in things they had not actually experienced if they were not given options that they had not actually experienced. A sampling of items to measure the aspects of motivation are in Table 2.

Table 2: Sample of items used to measure life experiences and their factor loadings

Designed & Built Things	I built model planes, cars, buildings, or other items with kits.
	I built things outside such as forts, tree houses, or other structures.
Did Creative Activities	I took lessons on/studied art.
	I did freehand sketches.
Played Video Games	I played computer games that require navigating a 3D environment.
	I played video games that require moving or locating objects.
Played Sports & Outdoor Activities	I played on an organized sports team.
	I played outside most of the time.

The last section was the Revised Purdue Spatial Visualization Tests: Visualization of Rotations (PSVT:R).[36] The 30 item test served as the measure of each participants' spatial skill level. This cognitive portion of the test was used to compare to the previous affective portions.

Sample

Of the 189 participants that finished the survey, several were incomplete. Most of the incomplete responses had large portions of missing data so all of the incomplete responses were entirely removed from the analysis. This yielded a total of 170 complete responses for analysis.

Participants were mostly male, Caucasian freshmen that were studying General Engineering. However, there were participants across a variety of ethnicities and from all student classifications, including graduate students. Other majors represented in the sample were Mechanical Engineering, Construction Science, Petroleum Engineering, and various other Engineering programs. Data on handedness was also gathered and 12.9% (n=22) of the participants were left-handed which is reflective of the population as a whole. A summary of the demographics of the participants is found in Table 3.

Table 3: Demographic information

Total Number of Participants: N = 170							
Gender		**Student Classification**		**College Major**		**Ethnicity**	
Male	135	Freshman	128	General Eng.	90	Caucasian	112
Female	35	Sophomore	10	Mechanical Eng.	27	Asian	18
		Junior	23	Construction Science	18	Hispanic	15
		Senior	1	Petroleum Eng.	11	African American	13
		Graduate	8	Other Eng.	24	Native American	4
						Other	8

Data Analysis

The motivational and early life experience data were first analyzed using exploratory factor analysis (EFA) using SPSS. For the motivation section, the three elements loaded onto three individual factors as expected. Each participant was then given a score for each of the individual motivational items that was then used in further analysis. An EFA was also carried out for the life experiences section. A follow-up confirmatory factor analysis was then done to confirm the number of factors and their loadings.

The spatial skills portion was analyzed using both analysis of variance (ANOVA) and independent samples t-test using the PSVT:R score as the data points. These were done to test whether there were differences on the various variables with respect to the participants' PSVT:R score. Polytomous variables were analyzed with ANOVA and dichotomous variables were analyzed with independent t-tests.

Pearson correlations were used to analyze the motivational items, the early life experiences items and the spatial skills scores together. The scores on the variables as generated by the factor analyses were correlated with the PSVT:R scores. This was done to assess whether there is a correlation between the level of spatial skills of participants and the magnitude of the motivational and early life experiences items.

Findings

Demographics

The demographic data were analyzed to assess whether there were differences in spatial skills across gender, ethnicity, major, and student classification. An Analysis of Variance test indicated that the effect of ethnicity on PSVT:R scores was significant, $F(4,165) = 3.25$, $p = .008$. Post hoc analyses indicated that the only difference in score found when comparing two ethnicity groups was between Caucasians (M=22.51, SD=4.95) and African Americans (M=17.23,

SD=6.14), p = 0.01. This could, however, be due to the fact that there was a large disparity in the number represented from each group (n=112 and n=13, respectively) so a larger and more diverse sample would be required to assess whether this is a significant finding. The non-Caucasian groups were combined to provide a more robust comparison of ethnicity since the non-Caucasian groups were not represented as highly. There was a difference in scores between the Caucasian group (M =22.51, SD=4.95) and the non-Caucasian group (M=19.88, SD=6.43), t(168) = -2.96, p = .004. The purpose of combining the non-Caucasian participants into one group is not to draw conclusions about these groups specifically (the authors recognize that these ethnic groups are distinct and unique). Rather, this was done in an effort to get more statistically meaningful results by organizing the data such that variable groups have a larger n.

The next demographic item analyzed was college major. The ANOVA indicated that the effect of college major on PSVT:R scores was significant, $F(4,165)$ = 5.86, p < .001. Post hoc analyses indicated that those in General Engineering (M=23.41, SD=4.69) were found to have the highest PSVT:R scores. They were statistically higher than students in both Mechanical Engineering (M=19.00, SD=5.86), p = .002, and Construction Science (M=19.06, SD=5.89), p = .02. This could also be a result of the disparity in the number of participants from each category.

The gender differences were then compared with an independent samples t-test. The data indicated no statistically significant difference between the male and female participants which is counter to the belief that men have better spatial reasoning skills than women. The null hypothesis of equal means could not be rejected, $t(168)$ = .62, p = .54. Table 4 below shows the results of the male and female participants.

Table 4: Descriptive statistics with scores by gender

Gender	N	Mean PSVT:R Score	Standard Deviation
Male	135	21.75	5.88
Female	35	21.09	4.51

Motivational Factors

Pearson correlations reveal the association between perceived instrumentality, self-efficacy, and epistemic beliefs and spatial ability (PSVT:R score).. The results indicated a strong, positive correlation between self-efficacy beliefs and spatial skills. No significant correlation was indicated between spatial skills and perceived instrumentality or epistemic beliefs (See Table 5).

Table 5: Correlation matrix of motivational factors and PSVT:R scores

	PSVT:R Score
Self-Efficacy Beliefs Score	0.44*
Perceived Instrumentality Score	-0.02
Epistemic Beliefs Score	<0.01

* = p < .001

Early Life Experiences

A series of Exploratory Factor Analyses using principal components analysis and varimax rotation were performed on the life experiences items to determine clusters of early life experiences that might predict spatial abilities. Twenty-two items loaded onto four distinct factors and all factor loadings were greater than .40. The first factor, *Designed and Built Things* included items such as playing with LEGO blocks, drafting by hand and computer, and building things outside. The second factor, *Did Creative Activities* included items such as taking art lessons and doing art projects, playing musical instruments, doing freehand sketches, and crafting. The third factor, *Played Video Games* included playing both computer and gaming console games that involved both three-dimensional and two-dimensional environments. The fourth factor, *Played Sports and Outdoor Activities* included items such as playing organized sports and other outdoor activities.

Mean scores on each of these factors were calculated and correlated with spatial ability. *Designed and Built Things* emerged as the only factor that was significantly associated with . The correlation was moderate at $r(168) = .24$., p= .001   (see Table 6).

Table 6: Correlation matrix of life experience factors and PSVT:R scores

	PSVT:R Score
Designed and Built Things	0.24*
Did Creative Activities	0.02
Played Video Games	0.05
Played Sports and Outdoor Activities	-0.10

* = p < .01

Self-Efficacy and Epistemic Beliefs

We predicted that epistemic beliefs that spatial abilities can be improved with training and practice would influence spatial ability, yet found not significant bivariate correlation. Given this perplexing finding, we ran a test of mediation to test the indirect effect of epistemic beliefs on spatial abilities through self-efficacy using the Hayes PROCESS macro in SPSS.[37] Our results indicate that self-efficacy beliefs serve as an intervening variable between epistemic beliefs and spatial skills, such that epistemic beliefs have a positive impact on self-efficacy beliefs which in turn have a positive impact on spatial skill scores.

Discussion

There are two main points of interest in the findings of this study. The first is regarding the results of the lived experiences analysis. The results showed a strong correlation between a high degree of designing and building things and a high level of spatial skills. This finding can be used to design and develop instructional interventions. Knowing that activities that involve designing and building, primarily with one's hands, correlates highly with spatial skills can guide instruction. While it cannot be proven that these kinds of activities are causal (it could be that those with high spatial skills choose to engage in these sorts of activities), the strong correlation is a good indicator that interventions guided by actually engaging in the design process and following it through to bringing the design to fruition is a powerful method of developing strong spatial skills.

The second point of interest is the idea of the impact of epistemic beliefs on spatial skills. The fact that it is mediated by self-efficacy beliefs is additionally interesting. This finding indicates that a potentially successful intervention strategy may involve instruction related to the nature of knowledge. If those that believe they are not able to learn things beyond a certain point – that knowledge is fixed – are convinced that this is not the case and that they can expand their knowledge this could improve their scores. Since this belief about knowledge is impacting their confidence in their abilities, the new understanding of the nature of knowledge could serve to improve their confidence and in turn improve performance.

Limitations

The primary limitation of this study is the lack of diversity among the participants. We were able to get good analyses of how motivational and early life experiences impact spatial skills but were not able to investigate how this effect might vary across different demographics. We were also not able to make good comparisons of different demographic groups. Future studies will incorporate data from a more diverse set of participants.

Future Research

The authors' future research plan is to use the results of this study to implement and test the instructional interventions. The first intervention will focus on the instruction regarding the nature of knowledge and how this impacts self-efficacy beliefs and further impacts spatial skills. The testing will be done with students from varied backgrounds to assess how individuals studying in a variety of domains are impacted by their beliefs about knowledge and their own abilities. Subsequently, the researchers will develop interventions that are applicable in existing curricula. Such interventions will be informed by the knowledge that designing and building are correlated with a high level of spatial skills.

Bibliography

1. Martín-Dorta, N., Saorín, S. J., & Contero, M. (2008). Development of a fast remedial course to improve the spatial abilities of engineering students. Journal of Engineering Education, 97(4), 505-513.
2. Kell, H., Lubinski, D., Benbow, C., & Steiger, J. (2013). Creativity and technical innovation: Spatial ability's unique role. Psychological Science, 24(9), 1831-1836: quote on p. 1836.
3. Lord, T. (1985). Enhancing the visuo-spatial aptitude of students. Journal of Research in Science Teaching, 22(5), 395-405.
4. Zavotka, S. (1987). Three-dimensional computer animated graphics: A tool for spatial skill instruction. *Educational Communication and Technology, 35(3)*, 133-144.
5. Sorby, S. & Veurink, N. (2012). Spatial skills among minority and international engineering students. *Proceedings of the 119th ASEE Conference and Exposition.*
6. Voyer, D., Voyer, S., & Bryden, M. P. (1995). Magnitude of sex differences in spatial abilities: A meta-analysis and consideration of critical variables. *Psychological Bulletin, 117*(2), 250–70.
7. Masters, M. S., & Sanders, B. (1993). Is the gender difference in mental rotation disappearing? *Behavior Genetics*, 23(4), 337–41.
8. Hamilton, C.J. (1995). Beyond sex differences in visuo-spatial processing: The impact of gender trait possession. *British Journal of Psychology*, 86(1), 1-20.
9. Moe, A. (2009). Are males always better than females in mental rotation? Exploring a gender belief explanation. *Learning and Individual Differences, 19*(1), 21–7.

10. McGee, M. G. (1979). Human spatial abilities: Psychometric studies and environmental, genetic, hormonal, and neurological influences. *Psychological Bulletin, 86,* 889–918.

11. Immekus, J. C., & Maller, S. J. (2010). Factor structure invariance of the Kaufman Adolescent and Adult Intelligence Test across male and female samples. *Educational and Psychological Measurement, 70,* 91–104.

12. Levine, S. C., Vasilyeva, M., Lourenco, S. F., Newcombe, N. S., & Huttenlocher, J. (2005). Socioeconomic status modifies the sex difference in spatial skill. *Psychological Science, 16*(11), 841–45.

13. Hill, C., Corbett, C., & St. Rose, A., (2010). *Why so few? Women in science, engineering technology and mathematics.* Washington, DC: AAUW.

14. Linn, M. C., & Petersen, A.C. (1985). Emergence and characterization of sex differences in spatial ability: A meta-analysis. *Child Development, 56*(6), 1479–98.

15. Linn, M. C., & Petersen, A. C. (1986). A meta-analysis of gender differences in spatial ability: Implications for mathematics and science achievement. In J. S. Hyde & M. C. Linn (Eds.), *The psychology of gender: Advances through meta-analysis* (pp. 67–101). Baltimore, MD: Johns Hopkins University Press.

16. Sharps, M. J., Welton, A. L., & Price, J. L (1993). Gender and task in the determination of spatial cognitive performance. *Psychology of Women Quarterly, 17*, 71–83.

17. Sharps, M. J., Price, J. L., & Williams, J. K. (1994). Spatial cognition and gender: Instructional and stimulus influences on mental image rotation performance. *Psychology of Women Quarterly, 18*, 413–25.

18. Bergvall, V. L., Sorby, S. A., & Worthen, J. B. (1994). Thawing the freezing climate for women in engineering education: Views from both sides of the desk. *Journal of Women and Minorities in Science and Engineering, 1*, 323–46.

19. Contero, M., Naya, F., Company, P., & Saorín, J. L. (2006). Learning support tools for developing spatial abilities in engineering design. *International Journal of Engineering Education, 22*(3), 470–77.xxx22xxx

20. Feng, J., Spence, I., & Pratt, J. (2007). Playing an action video game reduces gender differences in spatial cognition. *Psychological Science, 18*(10), 850–55.xxx23xxx

21. Eliot, J., & Smith, I. M. (1983). *An international directory of spatial tests*. Windsor, Berkshire, UK: NFER-NELSON Publishing Company. (Out of print; available at http://drc.ohiolink.edu/handle/2374.OX/30660)

22. Sorby, S. A. (1999). Developing 3D spatial visualization skills. *Engineering Design Graphics Journal, 63*(2), 21–32.

23. Sorby, S. A. (2007). Developing 3D spatial skills for engineering students. *Australasian Journal of Engineering Education, 13*(1), 1–11.

24. Németh, B. (2007). Measurement of the development of spatial ability by mental cutting test. *Annales Mathematicae et Informaticae, 34*, 123–8.

25. Martín-Dorta, N., Saorín, S. J., & Contero, M. (2008). Development of a fast remedial course to improve the spatial abilities of engineering students. Journal of Engineering Education, 97(4), 505–13.

26. Sorby, S. A., & Veurink, N. (2010). Are the visualization skills of first-year engineering students changing? *Proceedings of the 117th ASEE Conference and Exposition*.

27. Bairaktarova, D., Reyes, M., Nassr, N., & Carlton, D. (2015). Spatial skills development of engineering students: Identifying instructional tools to incorporate into existing curricula. *Proceedings of the 122nd ASEE Conference & Exposition.*

28. Metz, S.S., Sorby, S.A., Berry,T., Seepersad, C., Dison, A.M., Allam, Y., Merrill, J., Peters,W., Pfister-Altschul, E., Baxter, S., Zhang, G., and Leach, J. (2011). Implementing Strategies to Improve Retention: Focus on Spatial Skills-Engineering Schools Discuss Successes and Challenges. *Proceedings of the 118th ASEE Conference and Exposition.*

29. Baenninger, M., & Newcombe, N. (1989). The role of experience in spatial test performance: A meta-analysis. *Sex Roles, 20*(5/6), 327–44.

30. Deno, J. A. (1995). The relationship of previous experiences to spatial visualization ability. *Engineering Design Graphics Journal, 59*(3), 5–17.

31. Onyancha, R., Towle, E., & Kinsey, B. (2007). Improvement of spatial ability using innovative tools: Alternative view screen and physical model rotator. *Proceedings of the 114th ASEE Conference and Exposition.*

32. Olkun, S. (2003, April). Making connections: Improving spatial abilities with engineering drawing activities. *International Journal of Mathematics Teaching and Learning*, 1–10.

33. Chiaburu, D. S. & Lindsay, D. R. (2008). Can do or will do? The importance of self-efficacy and instrumentality for training transfer. *Human Resource Development International*, 11(2), 199-206: quote on p. 200.

34. Bandura, A. (1997). Self-efficacy: The exercise of control. New York: W. H. Freeman and Company.

35. Muis, K. (2007). The role of epistemic beliefs in self-regulated learning. *Educational Psychologist*, 42(3), 173-190.
36. Maeda, Y., & Yoon, S. Y. (2011). Scaling the Revised PSVT-R: Characteristics of the first year engineering students' spatial ability. *Proceedings of the ASEE Annual Conference and Exposition.*
37. Hayes, A. (2009). Beyond Baron and Kenny: Mediation analysis in the new millennium. *Communication Monographs*, 76(4), 408-420.