Why our Current Conception of Spatial Skills is at Odds with Equity in Engineering Education

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Abstract

The purpose of this arts-based research paper is to critically examine the practice of spatial skills testing in engineering education research and practice. Many well-meaning educators and researchers have undertaken projects to help women students succeed in engineering by offering spatial skills training courses, under the premise that women lag behind men in spatial skills and that this contributes to their lower rates of participation in engineering. The practice of spatial skills testing and funneling students into remedial courses promotes a deficit model against women and Black, Hispanic/Latino/Latine, and Native American students of all genders, as these students disproportionately score lower on some widely used assessments that are thought to measure spatial skills, such as the Purdue Spatial Visualization Test (PSVT:R). The validity and fairness of these assessments is generally unquestioned.

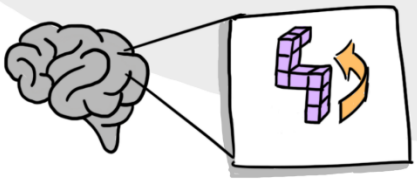
This paper takes the form of a "visual paper," which uses illustrations and minimal text to tell a story, similar to a comic strip. This visual paper highlights a growing body of research which questions the validity of popular spatial tests like the MRT and PSVT:R. The paper also discusses the history of spatial testing draws attention to the fact that many of the spatial tests used today were popularized not because of their ability to accurately measure a spatial construct, but simply because of their ability to demonstrate "gender differences." This paper draws attention to recent studies which indicate that spatial training interventions have not proven themselves to be effective at improving spatial skills, as measured by spatial tests. When the interventions do have good outcomes, such as promoting graduation rates, this is more likely due to the non-spatial aspects of the interventions, for example, the fact that the courses are majority women and provide peer networking opportunities.

When faced with the argument that existing spatial tests are gender biased or otherwise invalid, people often ask for a "better test." This paper uses recent literature to argue that instead of trying to find a better spatial skills test, we should reconsider the role that spatial skills actually play in training engineers. This paper argues that spatial skills testing and training interventions are a misuse of the time and energy of people who want to help women and other historically excluded students succeed in engineering. We must reframe our interventions without perpetuating deficit models about cognitive abilities like "spatial skills," a construct which, in spite of its wide popularity in the STEM education community, has been very poorly formulated.

INTRODUCTION

WHAT ARE SPATIAL SKILLS?

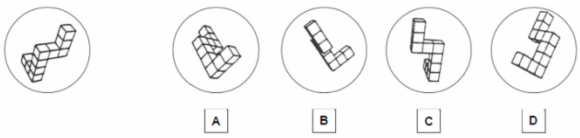
SPATIAL SKILLS ARE THOUGHT TO BE THE MENTAL ABILITY TO MANIPULATE OBJECTS IN SPACE.



SPATIAL SKILLS ARE MEASURED THROUGH STANDARDIZED TESTS. TWO WIDELY USED TESTS ARE...

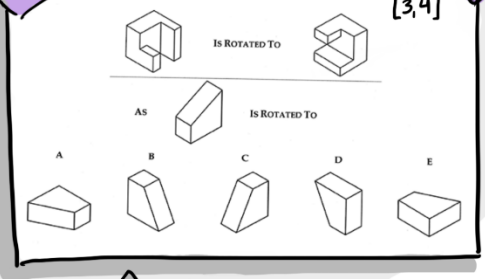
THE MENTAL ROTATION TEST (MRT)

[1,2]



PURDUE SPATIAL VISUALIZATION TEST : ROTATION (PSVT:R)

[3,4]



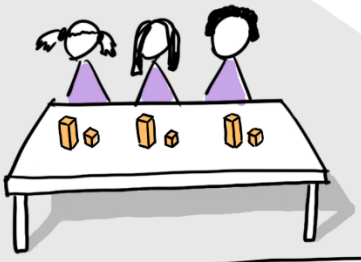
ON AVERAGE, MEN SCORE HIGHER THAN WOMEN ON THESE TWO TESTS. [5,6]

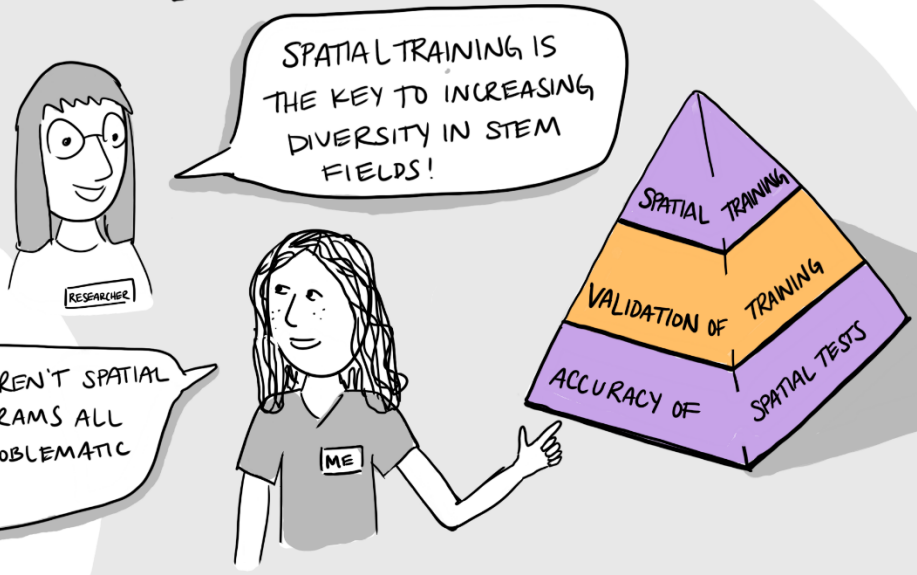
COMMON NARRATIVE

WHITE & ASIAN STUDENTS ALSO SCORE HIGHER THAN OTHER GROUPS ON THE PSVTR. [9]

WHY TRAIN SPATIAL SKILLS?

THE POPULAR NARRATIVE ARGUES THAT WE SHOULD TRAIN WOMEN'S SPATIAL SKILLS TO HELP THEM SUCCEED IN STEM. [7,8]





WHAT'S THE SCOPE OF SPATIAL TESTING & TRAINING?

GOOGLE SCHOLAR DATABASE SEARCH

YEARS: 2023 only
TERMS: "spatial ability"
RESULTS: **3920** PUBLICATIONS

TERMS: "spatial skills"
RESULTS: **2930** PUBLICATIONS

TERMS: "spatial skills" + training
RESULTS: **2100** PUBLICATIONS

NSF AWARD DATABASE SEARCH

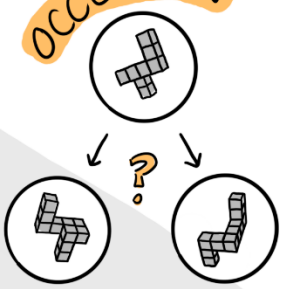
YEARS: 2018-2023
TERMS: "spatial skills" OR "spatial ability"
RESULTS:

45 AWARDS
totaling
$25.2 MILLION
IN FUNDING OVER THE PAST 5 YEARS

WHAT'S THE PROBLEM WITH SPATIAL TESTS?

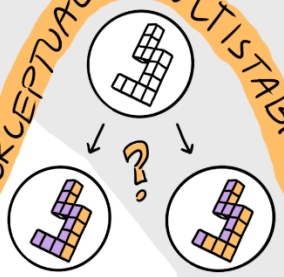
MANY SPATIAL TEST REQUIRE THE TEST-TAKER TO INTERPRET UNCLEAR 2D DRAWINGS OF 3D SHAPES. PEOPLE WITH A BACKGROUND IN ENGINEERING GRAPHICS HAVE AN ADVANTAGE.

OCCLUSION

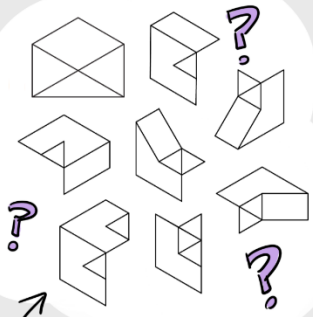


PART OF THIS MRT SHAPE IS HIDDEN FROM VIEW. WHEN ROTATED, IT COULD BE MULTIPLE DIFFERENT SHAPES. [10]

PERCEPTUAL MULTISTABILITY



WHICH INTERPRETATION IS CORRECT? [10]

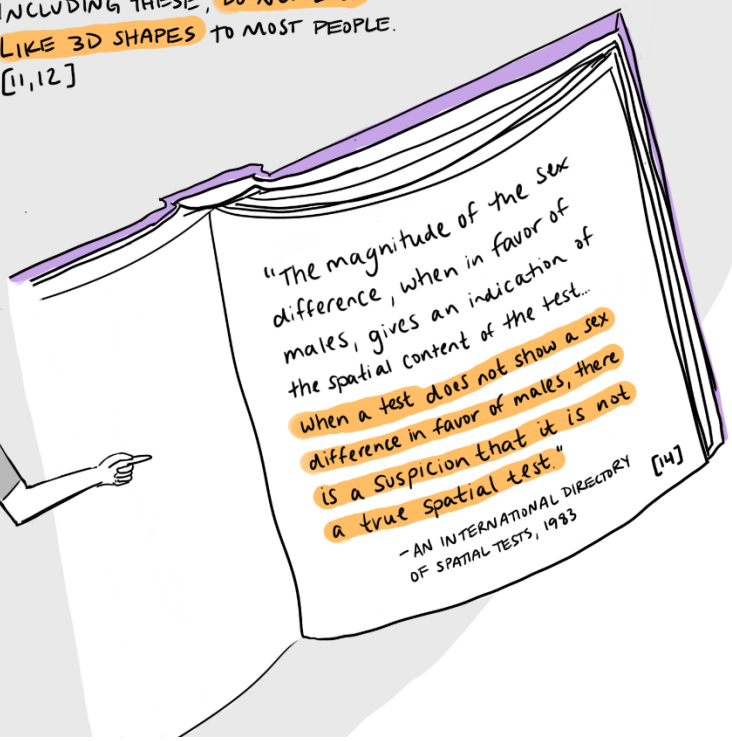


MANY SHAPES IN THE PSVT:R, INCLUDING THESE, DO NOT LOOK LIKE 3D SHAPES TO MOST PEOPLE. [11,12]

WOW! WELL, HOW DID TESTS LIKE THESE BECOME SO POPULAR?

TESTS LIKE THE MRT AND PSVT:R ROSE IN POPULARITY BECAUSE OF THEIR ABILITY TO DEMONSTRATE "GENDER DIFFERENCES."

"GENDER DIFFERENCES" WERE ONCE SEEN AS THE KEY TO MAKING A GOOD SPATIAL TEST! [13]




THIS HAS BECOME A SELF-FULFILLING, ILLOGICAL CYCLE
[13]
BELIEF THAT MEN HAVE BETTER SPATIAL ABILITY THAN WOMEN
TESTS WHERE MEN PERFORM BETTER THAN WOMEN ARE CONSIDERED TO BEST MEASURE SPATIAL ABILITY
THESE SAME TESTS ARE USED TO MEASURE "GENDER DIFFERENCES" IN SPATIAL ABILITY
OKAY, I SEE THE PROBLEM WITH SPATIAL TESTS, BUT WHAT'S THE ISSUE WITH SPATIAL TRAINING?
I'M GLAD YOU ASKED! SPATIAL TRAINING PROGRAMS HAVE NOT BEEN DEMONSTRATED TO IMPROVE STEM OUTCOMES, AND THEY PROMOTE DEFICIT MODELS.
[15]
"We lack clear evidence that Spatial training causally improves STEM Success."
[16]
Spatial training promotes deficit models by "reinforcing the idea that only those with the highest scores on spatial ability measures are capable of pursuing STEM careers." [17]

WHAT'S THE PROBLEM WITH SPATIAL TRAINING?

WHEN SPATIAL TRAINING PROGRAMS DO HAVE POSITIVE CORRELATIONAL OUTCOMES, LIKE HIGHER GRADUATION RATES, THIS COULD BE DUE TO **NON-SPATIAL FACTORS.** FOR EXAMPLE... [15]

peer networking

engineering identity

sense of belonging

RATHER THAN PERPETUATING HISTORICAL BIASES, OUR ENERGY WOULD BE BETTER SPENT ON INTERVENTIONS TO **MAKE THE STRUCTURE AND CULTURE OF ENGINEERING MORE WELCOMING TO ALL STUDENTS!**

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