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Establishing International Normative Values for Spatial Thinking Skills Across World's Cultural Regions: A Multilevel Investigation of Individual and Cultural Factors

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Abstract:

Spatial thinking skills are defined as the capacity to perceive, mentally transform, and reason about objects, locations, and spatial relationships. This capacity underpins fundamental competencies such as map reading, geometric reasoning, and scientific visualisation, and directly influences academic achievement in mathematics, science, and social studies, as well as long-term career trajectories and the performance of a wide range of professions (Arıkan, 2026; Uttal et al., 2013; Wai et al., 2009). Despite their recognised importance, research on spatial thinking skills has largely been conducted with small samples drawn from a single country or a few schools, relied predominantly on Western data sets, and remained limited to cross-sectional designs measuring only a single dimension. Most critically, cross-cultural norm values for the 12–18 age range have yet to be established in any published study.

In the present study, data will be collected from the same participants on three widely recognised sub-dimensions of spatial ability: spatial visualisation, mental rotation, and spatial orientation. These data will be examined through a holistic perspective afforded by two-level hierarchical linear modelling (HLM), which enables the simultaneous assessment of individual-level and cultural-region-level factors on spatial skills. The study will also establish norm values for spatial thinking skills from age 12 through 18.

However, maps are often visually cluttered, especially in urbanized or geographically complex areas, which limits the options for optimal text placement. The number of suitable positions is significantly reduced, once map labels interact with the map content. Other factors, such as colour contrast and the graphic map load, play an important role.

Expected contributions:

- The first international norm values for three sub-dimensions of spatial thinking skills for the 12–18 age group.
- Multilevel modelling of the effects of individual (gender, age, SES, school grades) and cultural (country of residence) factors on spatial thinking skills.
- An evidence base for the design of culturally responsive spatial skills curricula and early intervention programmes.
- An open dataset, norm tables, and analysis scripts to be archived on OSF/Zenodo for use by the wider research community.

• Quantitative, cross-sectional survey design • Multi-stage sampling: stratified → criterion → maximum variation • Eight world cultural regions (Tümertekin & Özgüç, 2019): Europe, Latin America, Slavic–Russian, Africa, Islamic, East Asian (China), East Asian (India), Pacific • Target sample: ≈420 participants per country (60 per age, 12–18) × 8 countries ≈ 3,360 participants	• Instrument: Spatial Reasoning Instrument (SRI; Ramful, Lowrie, & Logan, 2017): 30 items across 3 sub-dimensions × 10 items (Mental Rotation, Spatial Orientation, Spatial Visualisation) • Translation–back-translation procedure; expert panel review • Paper-and-pencil classroom administration (45–50 min) • Analysis: two-level HLM (individual & cultural region levels); calculation of age-specific norm values; SPSS version 28.0

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