Spatial Education Across the College Curriculum: A Psychologist’s Perspective

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It is both exciting and challenging to participate in a meeting attempting to design college curricula that will both enhance students’ spatial thinking and attract support of faculty, students, and administrators. Having been asked to prepare a position paper from my perspective as a psychologist who has worked at the intersection of spatial thinking and science education, I offer a list of what I believe to be the most critical directions for our collective work. Given space constraints, I amplify only the first three points, drawing on illustrations from my prior research.

In take-home message form, I would urge that we should:

• Identify overarching conceptualization(s) of space and spatial thinking that can provide the organizing structure for curricula.
• Draw on developmental theory and empirical research to identify spatial challenges. What is difficult for all children is likely to be difficult for a non-trivial number of adults.
• Partner with discipline-specific faculty (e.g., geographers, geologists, engineers) to identify points of contact and test hypothesized spatial-skill-discipline-mastery links.
• Establish and test the impact of instructional formats for enhancing disciplinary mastery via spatial education, e.g., pairing spatial and discipline courses, requirements, or assignments (as in “writing in the disciplines” programs).
• Replace the Faith-based School of Spatial Education with the Research-based School of Spatial Education as data (see above) allow. Despite demonstrated malleability of performance on specific spatial tasks, the current database is simply too limited to demonstrate the positive impact of a general spatial curriculum, identify necessary skill thresholds, etc.
• Consider (and test) the role of affective (motivational) as well as cognitive factors. As Evangelists of Spatial Education, we appear to assume that others need only be shown The Way and they will wish to join the fold. But to the degree that students see themselves as weak in spatial skills, hold essentialist views about spatial abilities, find spatial challenges uninteresting or even aversive, and see little self-relevance, they may be an unreceptive audience. We must evaluate outcomes of a spatial curriculum in relation to students’ initial interests, beliefs, and goals; study if and how these change with instruction; and modify programs as needed to respond to observed student diversity.
• Address the developmental pipeline. A college spatial curriculum cannot ignore the filtering and educational processes that determine who matriculates and with what entry-level skills and interests. Insights from work involving primary- and secondary-school students may inform college instruction, could lead to strengthening pre-college spatial education, and might ultimately result

1 Throughout this essay, the first-person collective refers to the community of spatial educators and scholars
in establishing spatial prerequisites or entry-level placement tests like those required for other skill sets (e.g., mathematics; writing).

• **Brief amplifications and illustrations of the first three points:**
  Spatial conceptual systems. The goal of designing a curriculum to foster an understanding of “space” and enhance “spatial skills” requires identifying what these terms entail. I would suggest that there is a too-common tendency to equate space with location, and to equate spatial thinking with analyzing phenomena in relation to geographic location. Spatial thinking is more than this. Arguably one of the most important steps we can take toward the goal of facilitating students’ spatial thinking is to establish one or more overarching conceptualizations of spatial concepts that students should master. To illustrate, consider Piaget’s argument that children first construct topological (T) concepts and later, in tandem, projective (P) and Euclidean (E) concepts. Leaving aside controversies about sequence, the TPE proposal carries implications about tasks that should pose interrelated challenges, exercises that should advance mastery, and contexts in which transfer should occur. Although I would not argue for this system in particular, I would argue for some overarching system (e.g., see Manduca & Kastens, 2012; National Research Council, 2006) to organize curricula and avoid instructional approaches that are random collections of spatial skills \textit{du jour}. An integrated conception of space might also be used to foster students’ spatial meta-cognition (e.g., practice analyzing how a particular task taps general spatial concepts or models might in turn promote students’ recognition of parallel spatial demands of a new task, thereby aiding transfer).

  Developmental insights into spatial challenges for adults. The above approach led Piaget to devise various projective and Euclidean spatial tasks. Although he implied effortless and universal mastery by late childhood, later researchers discovered that adults also err. Illustrative are findings on the water level task (WLT) which asks respondents to draw lines inside tipped bottles to show water positions. Even some adults fail to represent the water as invariantly horizontal (Liben, 1991), an error interpreted as indicating the person’s difficulty in establishing and using stable axes (e.g., the horizon) in the face of distracting referents (the bottle’s sides). These data suggest that some college students need to develop greater facility with coordinate axes, and, more generally, with frames of reference (FOR) (e.g., constructing FORs, identifying alternative FORs, relating multiple FORs, selecting among FORs).

  Interdisciplinary partnerships. I use collaborative work with geologists to illustrate links between spatial concepts studied by developmental psychologists and college students’ science learning. In one study (Liben, Kastens, & Christensen, 2011) we hypothesized that students who performed badly on the WLT would have difficulty learning the geological concepts of strike and dip (requiring identification of horizontal and vertical axes in non-orthogonal contexts). Pretests identified college students with excellent, moderate, or poor WLT scores who were then taught about and tested on mapping an outcrop’s strike and dip. As hypothesized, strike and dip accuracy varied across WL groups (as did the use of observational strategies and accuracy in pointing to North). In another project aimed at synthesizing cognitive and Earth science, we (Liben & Titus, 2012) examined the spatial demands and skills entailed in a narrative description
of a day of a structural geologist’s fieldwork and discussed implications for educational directions. Both studies have implications for spatial curriculum.

**Beyond this position paper:**
Although it is impossible to develop the full set of take-home messages here, I hope that the list provides some useful topics for our collaborative discussion in December. Information on cited references follows.


