What does Space look like in CS? Mapping out the Relationship between Spatial Skills and CS Aptitude

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ABSTRACT

Spatial skills are cognitive skills relating to the mental consolidation of spatial structures and operations. Rotating shapes in one's head, identifying patterns from obscured environments and parsing 3D structures from 2D representations are some tasks which require spatial skills. It is fairly easy to see how spatial skills – literally, skills to do with space – are associated with success in STEM domains: 3D modelling in engineering, understanding molecular structure in chemistry and conceptualising kinematics in physics. This connection is less clear for CS, where concepts of space are more abstract and can be thought unrelated to problems that programmers typically face [5]. And yet, spatial skills are correlated with CS success and training spatial skills improves CS outcomes. We are left asking: "What does space look like in CS?"

Parkinson & Cutts associate spatial skills with visualisation and mental modelling skills [3], and Margulieux's Spatial Encoding Strategy theory stipulates that developing spatial skills improves one's capacity to encode mental representations of non-verbal information [2]. This permits processing of more non-verbal information rapidly through effective chunking, freeing up space in working memory (WM) for more complex operations and concurrent representations. That is, effective encoding strategies – related to spatial skills – allow more non-verbal information to be retained in WM and for multiple mental models to be held at once.

But how does this look in CS specifically? In this abstract we highlight some existing research in our initial findings which point towards CS success depending – at least in part – on encoding strategies:

- Loksa *et al.* describe a sequence of programming problem solving with steps which require students to maintain understanding or representations internally as they perform more operations, with two explicitly saying, "With a ... solution in mind" [1].
- Wing identifies a component of computational thinking as, "working with multiple layers of abstraction and understanding the relationships among the different layers", explicitly indicating that holding multiple representations at once is valuable [6].
- Robbins examines Dual Process Theory as a context for exploring cognition in CS. Of particular interest is the application of System 2, the "slow, reflective" system which encompasses WM and mental models, and is argued to explain successes in multiple CS contexts [4].

These are just some examples of theories and strategies applied in CS which appear to depend on non-verbal encoding skills and therefore are related to spatial skills. We will present several connections by tying many perspectives of skills required for computing success back to non-verbal encoding skills, thus providing a model of the relationship between CS and spatial skills.

Our goal with this poster is to solicit feedback on our model from the ICER community, from spatial skills factors all the way to application in CS. We want to hear perspectives on CS skills and attributes that we may have missed and determine if they relate to non-verbal encoding. Finally, we want to continue the discussion of spatial skills and abstract cognitive skills at ICER, a venue which has shown appreciation for these ideas in the past.

CCS CONCEPTS

• **Social and professional topics → Computing education**.

KEYWORDS

spatial skills, cognition, abstract skills, problem solving, encoding

ACM Reference Format:
Jack Parkinson. 2022. What does Space look like in CS? Mapping out the Relationship between Spatial Skills and CS Aptitude. In *Proceedings of the 2022 ACM Conference on International Computing Education Research V.2 (ICER 2022), August 7–11, 2022, Lugano and Virtual Event, Switzerland.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3501709.3544284

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ICER 2022, August 7–11, 2022, Lugano and Virtual Event, Switzerland

ACM ISBN 978-1-4503-9195-5/22/08.
https://doi.org/10.1145/3501709.3544284

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