Systems Thinking Factors as Predictors of Success in an Engineering Design Task

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1. Introduction

- Engineering design is a cognitive task, and one that is influenced by the way that the designer is thinking; to be a successful designer, one must think a certain way.
- Systems thinking is the type of thought that allows a designer to be successful in systems design, and is made up of many cognitive competencies[1]
- Certain cognitive competencies are likely more relevant to engineering design than others – but which?
- The purpose of the present study was to investigate how psychological measures of cognitive competencies are related to success on a design task, and to see which, if any, were significant predictors of design outcome variables.

2. The Empirical Study

- To analyze the relationships between a designer's cognitive competencies and their success on a design task, participants engaged in a week-long computer-aided design challenge, after which they completed a set of psychological tasks.
- *n* = 49, (38 male, 11 female; mean age = 22.91, SD =4.38, 39 undergraduate, 10 graduate)

3. Measures: The Design Task

- To measure design success, participants used the computer-aided design software Energy3D[2], to compete against each other to offer a design that would help solarize a local university campus.
- Designers were faced with very ambitious goals and hindered with many constraints; see the table below for an overview.

	Variable	Benchmark
Goals	Annual Energy Output	1,000,000 kWh
	Payback Period	10 years
Constraints	Budget	$1,900,000
	Solar Panel Model	Choose 1 of 3 options
	Panel Height	≥ 3.5m, depending on the Tilt Angle
	Panel Width	5.25m - 6m
	Panel Placement (overall)	Panel edges must not overlap
	Panel Placement (in parking lot)	≥ 7.8m from the closest panel

4. Measures: Cognitive Competencies

- We draw from literature on systems thinking, and measure designers across five constructs using five psychological tests; see the table below.

Systems Thinking Cognitive Competency	Psychological Test(s)
Divergent Thinking of Creativity	Alternate Uses Task (*AUT*)[3]; Abbreviated Torrance Test for Adults (*ATTA*)[4]
Cognitive Ability	International Cognitive Ability Resource (ICAR)[5]
Working Memory	Keep Track test[6]; n-back test
Imagination	Four Factor Imagination Scale (*FFIS*)[7]
Personality	Big Five Inventory (*BFI*)[8], Openness to Experience

5. Results

Regressions

- Four models to predict four outcomes; none were significant

Correlations

- Two significant correlations;
- Fluency and Total Cost
  $p = 0.039$
- Fluency and Total Output
  $p = 0.039$

	Linear Regressions		Correlations								
	p-value	Adjusted R^2	Working Memory	Cognitive Ability	Divergent Thinking - Fluency	Divergent Thinking - Originality	FFIS - Complexity	FFIS - Frequency	FFIS - Directedness	FFIS - Emotional Valence	Openness to Experience
Output / Cost	0.811	-0.095	0.100	0.077	0.057	0.089	-0.008	-0.029	-0.208	-0.113	0.022
Total Cost	0.663	-0.054	0.106	0.027	**0.293**	0.122	0.068	-0.122	0.007	-0.064	0.005
Total Output	0.656	-0.052	0.153	0.057	**0.292**	0.168	0.065	-0.115	-0.055	-0.106	-0.022
Payback Period	0.739	-0.074	-0.156	0.009	-0.141	-0.100	0.005	0.084	0.144	0.121	-0.009

6. Discussion

- One of the cognitive competencies that designers were measured was found to be significantly positively correlated to two measures of their performance on the design task.
- However, none of the predictive linear models were significant, and failed to explain any variance.

7. References

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