



Construct Analysis of Computational Thinking

Presentation to the DAC

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Presentation Overview

- Project Overview
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 - Computational Thinking Content Domain Descriptions
 - Approach Overview
 - Considerations
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William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (HR 6395), Section 594

“Not later than one year after the date of the enactment of this Act, the Secretary of Defense shall establish a special purpose test adjunct to the Armed Services Vocational Aptitude Battery test to address computational thinking skills relevant to military applications, including problem decomposition, abstraction, pattern recognition, analytical ability, the identification of variables involved in data representation, and the ability to create algorithms and solution expressions.”

Note: The date for meeting this requirement has been adjusted to October 1, 2024.

Computational Thinking Content Domains and Descriptions

- Problem decomposition
 - Breaking down a problem/task into smaller/easier components (e.g., describe a system as a sequence of processes)
- Abstraction
 - Focusing on most relevant information and ignoring extraneous information to interpret meaning and reduce complexity of a problem/task
- Pattern recognition
 - Identifying and using repeated information or patterns to predict outcomes or determine actions for a problem/task

Computational Thinking Domains and Descriptions (continued)

- Identification of variables involved in data representation
 - Recognizing how parts of a solution may be reapplied to or eliminated from similar or unique problems/tasks
- Analytical ability
 - Inspecting, cleansing, transforming, and modeling data with the goal of discovering useful information for a problem/task
- Ability to create algorithms and solution expressions
 - Recognizing and evaluating options against outcomes to simplify or automate processes for efficiency and resource utilization improvements

Approach Overview

What We Know

- A measure of Computational Thinking does not currently exist within ASVAB/military testing
- NDAA timeline does not support creating a new, valid measure of Computational Thinking
- Existing ASVAB/military tests potentially measure the content domains underlying the Computational Thinking construct
- A means to assess the six (6) content domains of Computational Thinking must be operational by October 1, 2024

What We Are Planning

- Phase 1: Conduct alignment study to establish Computational Thinking composite from existing ASVAB and military tests
 - Collect SME judgments linking existing military tests to Computational Thinking content domains
 - Use (estimated) correlations among tests and to Computational Thinking content domains to generate Computational Thinking composite
 - Deliver composite specifications to DTAC by September 30, 2023, for platform modifications
 - Implement operationally on October 1, 2024
- Phase 2: Conduct empirical validation study of Computational Thinking composite score

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Project Considerations

- Intended use of Computational Thinking composite score
 - Selection vs. classification vs. both
- Weighting of Computational Thinking domains
 - Overall vs. occupation-specific
- Ease of implementation (e.g., platform modifications required; testing time requirements)

Phase 1: Alignment Study

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Alignment Study – Objectives

- Establish viable Computational Thinking composite score from existing ASVAB and/or military tests
 1. Collect SME judgments of linkages between ASVAB/military tests and Computational Thinking content domains
 2. Estimate correlations among ASVAB/military tests
 - Empirically estimated, when available (e.g., among ASVAB subtests)
 - SME-estimated, when *not* available (e.g., between pairs of military tests that have never been administered together)
 3. Use 1 and 2 to derive Computational Thinking composite score

Alignment Study – Approach Overview

- Update literature review to inform Computational Thinking content domain definitions
- Identify and recruit SMEs (I/O psychologists; military testing experts)
- Identify military tests of interest
- Obtain available correlations among ASVAB and military tests of interest
- Develop linkage exercise and data collection tools
- Collect linkage data from SMEs
- Analyze data and summarize results
- Provide composite score specifications to DTAC by September 30, 2023

ASVAB and Military Tests – Under Consideration

ASVAB Subtests	New ASVAB Test	Military Tests
Arithmetic Reasoning (AR)	Complex Reasoning (CR)*	Cyber Test (CT)
Mathematical Knowledge (MK)		Electronics Data Processing Test (EDPT)
Paragraph Comprehension (PC)		Mental Counters Test (MCt)
Word Knowledge (WK)		Coding Speed (CS)
Auto/Shop Information (AS)		
Electronics Information (EI)		
General Science (GS)		
Mechanical Comprehension (MC)		
Assembling Objects (AO)		

*Complex Reasoning Test is currently being researched and developed by DTAC/HumRRO team.

Alignment Study: Linkage Framework for SME Judgments

	ASVAB/ETP Subtest									New Test	Service Test			
Computational Thinking Content Domain	AR	MK	PC	WK	AS	EI	GS	MC	AO	CR	CT	EDPT	MCt	CS
Problem decomposition														
Abstraction														
Pattern recognition														
Analytical ability														
Identification of variables involved in data representation														
Ability to create algorithms and solution expressions														

Alignment Study: SME Judgment Exercise

- SMEs will be trained in live, virtual session; data will be collected asynchronously
- SMEs will be asked to estimate the following correlations:
 - among each of the six (6) Computational Thinking content domains
 - between each military test of interest and each of the six (6) Computational Thinking content domains
 - between pairs of military tests (if empirical estimates do not exist)
- All correlation estimates will be made assuming:
 - No range restriction (i.e., applicant population)
 - Highly reliable measures for both predictors and Computational Thinking content domains

Alignment Study – Materials Needed

- For Computational Thinking:
 - Definition of each of the 6 content domains
 - Estimated correlations among the 6 content domains (to be estimated by SMEs as part of the data collection)
- For each military test of interest:
 - Test blueprint, including definitions of all content domains
 - 2–3 non-operational sample items for each content domain
 - Estimated correlations among all military tests
 - If unavailable for some test pairs, we will need to gather estimates from SMEs as part of the data collection

Alignment Study – Timeline

Tasks	Start Date	End Date
Material Acquisition and Data Collection Preparation	11/1/2022	1/31/2023
Exemption Determination Official (EDO)/IRB Review, as needed	12/1/2022	1/31/2023
SME Recruitment	1/3/2023	1/31/2023
SME Data Collection	2/1/2023	2/28/2023
Data Cleaning, Analysis, and Reporting	3/1/2023	4/30/2023

Phase 2: Evaluation Study

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Evaluation Study – Objective

- Validate Computational Thinking composite score derived from the synthetic equation developed in Alignment Study (Step 1) using a Computational Thinking score based on administration of Computational Thinking marker instrument(s)
 - Using military applicants/recruits (or similar population)
- Evaluate the Computational Thinking composite score with respect to:
 - Score distributions
 - Subgroup differences
 - Other pertinent outcomes to be determined

Evaluation Study – Approach Overview

- Specify data collection method and participant recruitment strategy
 - Target population, sampling approach, sample size requirements
- Modify platform or create other tools (e.g., Qualtrics, HumRRO's platform) to administer required tests for study (i.e., ASVAB/military tests, Computational Thinking marker instrument(s))
- Recruit study participants
- Administer relevant assessments
- Compute correlations between Computational Thinking composite score and scores from Computational Thinking marker instrument(s)
- Conduct analyses to evaluate other pertinent outcomes

Evaluation Study – Timeline (TBD)

Task	Start Date	End Date
Computational Thinking Composite Specifications		09/30/2023
Validation Study – Design Study & Preparation	TBD	TBD
Validation Study – Data Collection	TBD	TBD
Validation Study – Analyses	TBD	TBD
Validation Study – Reporting	TBD	TBD

- Timeline determined by:
 - Composite score viability
 - Sample specifications (applicants/recruits OR representative sample)
 - Platform modifications and/or other data collection tool requirements and timelines
 - Sample recruitment timeline

Evaluation Study – Data Collection Strategies

Strategy	Population	Procedure	Strengths	Considerations
Option 1	Applicants and recruits	<ul style="list-style-type: none"> Use scores from iCAT or PiCAT (with verification) and AO Administer CT, MCt, CS, EDPT, as needed Administer CR & CompT 	<ul style="list-style-type: none"> Uses ASVAB subtest data from applicants/recruits Will not need to build and administer data collection tool for all assessments of interest 	<ul style="list-style-type: none"> Coordination with MEPCOM & Recruiting Ops Need iCAT/PiCAT(with verification) examinees to participate in other testing Not all Services administer Cyber Test, MCt, CS, EDPT
Option 2	Random sample of individuals representative of ASVAB examinees	<ul style="list-style-type: none"> Administer subset of items from ASVAB subtests of interest, including AO Administer CT, MCt, CS, EDPT, CR & CompT 	<ul style="list-style-type: none"> Avoids need to coordinate with MEPCOM/Recruiting Ops to identify applicants and recruits available to sample 	<ul style="list-style-type: none"> Need to build and administer subset of items from each test/subtest of interest to all study participants Study participants may not be representative of or as motivated as ASVAB examinees Sampling items from ASVAB dimensions may impact score reliability and validity

Next Steps

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Next Steps

- Finalize plans for the alignment study
- Obtain ASVAB/military test resources (e.g., blueprints, example items, available correlation data)
- Submit final research plan by end of calendar year
- Complete EDO/IRB review process (as necessary)
- Prepare data collection tools for alignment study
- Recruit SMEs and implement data collection

DAC Guidance & Questions

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DAC Guidance & Questions

- Alignment Study
 - Suggestions for SMEs?
 - Any other suggestions (or concerns) to consider?
- Evaluation Study
 - Any suggestions (or concerns) to consider?