Computational Thinking Update

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Briefing Agenda

- Background Information
- Phase 1: Computational Thinking Score Development
- Phase 2: Computational Thinking Validation Study
- Q&A

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Background Information

- William M. (Mac) Thornberry National Defense Authorization Act (NDAA) for Fiscal Year 2021 (HR 6395), Section 594
  - Must assess six (6) Computational Thinking domains
    - Problem Decomposition
    - Abstraction
    - Pattern Recognition
    - Analytical Ability
    - Identifying Variables for Data Representation
    - Creating Algorithms and Solution Expressions
  - Must be available for operational use by October 1, 2024

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Computational Thinking Construct Domains

Construct Domains	Descriptions
1. Problem decomposition	▪ Break down a problem/task into smaller/easier components (e.g., describe a system as a sequence of processes)
2. Abstraction	▪ Focus on the most relevant information and ignore extraneous information to interpret meaning and reduce complexity of a problem/task
3. Pattern recognition	▪ Identify and use repeated information or patterns to predict outcomes or determine actions for a problem/task
4. Analytical ability	▪ Inspect, cleanse, transform, and model data with the goal of discovering useful information for a problem/task
5. Identifying variables for data representation	▪ Recognize how parts of a solution may be reapplied to, or eliminated from, similar or unique problems/tasks
6. Creating algorithms and solution expressions	▪ Recognize and evaluate options against outcomes to simplify or automate processes for efficiency and resource utilization improvements

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What We Knew When We Started

- Existing measures of computational thinking assess some but not all six domains and are typically used within the K-12 classroom environment
  - Some have been developed for job selection; however, they require specific programming language skills
- A means to assess the 6 content domains of Computational Thinking must be operational, per the NDAA, by October 1, 2024
  - Timeline does not support creating a new, valid measure of Computational Thinking
- Existing ASVAB/special tests and the new Complex Reasoning Test may potentially assess all or some of the 6 Computational Thinking domains
  - Initiated an alignment study to derive a Computational Thinking score equation in February 2023

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Phase 1: Computational Thinking Score Development

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Phase 1: Alignment Study (completed)

- Collected SME judgments of estimated correlations between:
  - All 6 Computational Thinking content domains
  - All ASVAB subtests/special tests where empirical correlations do not already exist
  - Computational Thinking content domains and ASVAB subtests/special tests
- Conducted analyses to identify ASVAB subtests/special tests estimated to predict computational thinking construct
- Ran 5 different regression models to identify those estimating highest levels of prediction
- Identified three ASVAB subtests/special tests for inclusion in a score equation
  - Complex Reasoning (CR)
  - Arithmetic Reasoning (AR)
  - Cyber Test (CT)

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Response to DAC August 2023 Recommendations

- *Electronic Data Processing Test*: Remove from further research
  - Implemented (see slide 9)
- *Fairness*: Examine impact of subtest selection for composite score on subgroup differences
  - Implemented (see slide 11)
- *Validation*: Consider determining weight estimates for the six Computational Thinking (CompT) domains separately and then create a CompT composite by military occupation
  - Additional data collection would be required to validate occupational-specific composites to other performance-based criteria (e.g., training success; job performance). However, Phase 2 data along with the ASVAB training relevance survey results may be leveraged to conduct some exploratory analyses.

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Phase 1: Prediction Models Evaluated (completed)

Model	AR	MK	PC	WK	AS	EI	GS	MC	AO	CT	McT	CS	CR
Model 1: All tests	X	X	X	X	X	X	X	X	X	X	X	X	X
Model 2: All tests except CR	X	X	X	X	X	X	X	X	X	X	X	X	
Model 3: CR + AR + CT	X									X			X
Model 4: CR + AR	X												X
Model 5: CR + CT										X			X

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Phase 1: Model Selection and Evaluation (completed)

- Used initial findings from 5 models to identify those that maximized prediction of CompT, which were the last 3 models evaluated
  - Model 3 = CR + AR + CT
  - Model 4 = CR + AR
  - Model 5 = CR + CT
- Further evaluated the 3 models, with and without double-weighting CR
  - Estimated validity coefficients
  - Estimated subgroup difference effect sizes
  - Administration policy factors (e.g., CT not administered to all examinees)

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Phase 1: Results for Prediction Models

Component Tests	Analysis Method	Weights	Estimated Multiple R	Estimated Effect Size (d) M-F	Estimated Effect Size (d) NHW-HW	Estimated Effect Size (d) NHW-NHB
CR, AR, CT	NNLS	OLS	0.79	N/A	N/A	N/A
	NNLS-Equal Unit	CR=1; AR=1; CT=1	0.74	0.28	0.31	0.65
	NNLS-Weighted	CR=2; AR=2; CT=1	0.77	0.23	0.28	0.63
	NNLS-Weighted	CR=2; AR=1; CT=1	0.76	0.18	0.23	0.53
CR, AR	NNLS	OLS	0.79	N/A*	N/A	N/A
	NNLS-Equal Unit	CR=1; AR=1	0.78	0.15	0.23	0.58
	NNLS-Weighted	CR=2; AR=1	0.78	0.06	0.15	0.46
CR, CT	NNLS	OLS	0.73	N/A	N/A	N/A
	NNLS-Equal Unit	CR=1; CT=1	0.68	0.20	0.21	0.43
	NNLS-Weighted	CR=2; CT=1	0.72	0.10	0.14	0.36

*The estimated effect sizes (d) for subgroup comparisons were not calculated for the non-negative least-squares (NNLS) regression analyses with ordinary least-squares(OLS) regression weights given these models are not under consideration for the Computational Thinking (CompT) score.

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Phase 1: Computational Thinking Scores

- Computational Thinking scores = Weighted sum of CR/AR/CT standard scores
  - CompT_AR = 2(CR score) + AR score
    - Range = 0 to 300
  - CompT_CT = 2(CR score) + CT score
    - Range = 0 to 300
  - CompT_All = 2(CR score) + AR score + CT score
    - Range = 0 to 400

ASVAB, CT, and CR = Standard (T) score*

Mean = 50; Standard Deviation = 10

Range = 0 to 100

* CR standard (T) score is normed to the eligible military applicant population, but the transformation parameters were estimated in a sample different from the PAY97 sample.

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Phase 1: Computational Thinking Software Specifications

- Platform development is underway
  - Targeting August 2024 release (ahead of the October 1st mandate)
  - Working with MEPCOM to be ready to receive the 4 new scores (CR + 3 CompT scores)
- Completing CR will trigger the attempted calculation of CompT scores
  - CompT scores shall require AR and/or CT scores for calculation
  - CompT scores shall depend on AR and CT scores within the last 2 years
  - CompT scores shall be calculated from the most recent AR and CT scores available when multiple records are found
  - CompT scores could be blank if system does not locate an AR or CT score within the 2-year period it searched
- For each CompT score, save calculated score within the examinee's CR record
- All 4 scores (CR + 3 CompT scores) will be sent to MEPCOM

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Phase 2: Computational Thinking Validation Study

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Phase 2: Validation Study Requirements

- Selected Computational Thinking Assessment for Middle Grades (CTA-M) as marker test (slide 16)
- Established data collection plan (slide 17)
  - Obtained MEPCOM approval to collect data at MEPS with shippers (similar approach as Calculator Study)
- Verified viability of using Qualtrics at MEPS for data collection
  - Verified Qualtrics URL is accessible at MEPS and transitioned CR items from pilot test study to new account
  - Evaluated viability of using screenshots of marker test items in Qualtrics (as opposed to redrawing graphics)
- Prepared and user-tested data collection instrument in Qualtrics
  - CR test instructions and items
  - Computational Thinking marker test (CTA-M) instructions and items
  - Background questions
- Worked with MEPCOM to distribute communications and conduct virtual training sessions with Test Administrators (TAs) to initiate data collection at MEPS

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Phase 2: Evaluation of Computational Thinking Marker Tests

Test	# Items	Time	Pros	Cons
Computational Thinking Test (CTt)	28	45 mins	Content and criterion validity evidence	Designed for classroom use with middle school students; does not assess all 6 domains
Computational Thinking Assessment for Middle Grades (CTA-M)*	25	45 mins	Removes easiest CTt items, adds Bebras items (analytical thinking)	Designed for classroom use with middle school students; does not assess all 6 domains
Callysto Computational Thinking test (CCTt)	34	45 mins	Reduces CTt items, adds more challenging Bebras items	Includes attitude, experience, and efficacy items; does not assess all 6 domains
Algorithmic Thinking Test for Adults (ATTT)	20	70 mins	Measures computational, algorithmic thinking in adults (college level)	Very difficult; STEM majors scored significantly higher than Social Science majors; does not assess all 6 domains

* Indicates marker test selected for validation study

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Phase 2: Data Collection Approach

Who?	Where?	What?	How?	Considerations
Shippers who completed ASVAB plus Cyber Test (CT)	At MEPS following Calculator Study data collection (used same approach)	Administered: -Background Questions -Complex Reasoning (CR) -Marker Test (CTA-M)	Shortly after completion of Calculator Study data collection, began Computational Thinking data collection by switching instructions and URL to administer tests via Qualtrics	Shippers who completed CT were offered opportunity to participate Administered only CR and CompT marker test, along with background questions, which was estimated to take less than 1.5 hours Targeted N = 650 shippers with scores on AR, CT, CR, and CompT marker test
Advantages	• Collected data within military examinee population • Maintained security of tests • Leveraged Calculator Study protocol, which minimized changes for MEPS			

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Phase 2: Data Collection

- Data collection initiated after the Calculator Study completed
  - Pilot tested the training and Qualtrics URL with Technical Control Officers (TCOs) at Louisville and Minneapolis MEPS
  - Conducted virtual training sessions with MEPS TAs
  - Sent training slides, manual, and sign-up sheets (rosters) to MEPCOM for distribution to MEPS
- Targeted data collection from 650 participating shippers with AR and CT scores
  - Limited volunteers to shippers who completed CT
  - Estimated data collection to take one month based on prior years' MEPS data

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Q&A

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Guidance from the DAC

- Any feedback or suggestions on current data analysis plan?
  - Regression analyses of 3 CompT scores with CTA-M (marker instrument) scores as criterion
  - Subgroup difference effect size analyses (to extent data are available and sufficient)
  - Exploratory construct validity analyses using Phase 2 data, which include
    - Operational (“official”) scores on each ASVAB subtest and Cyber Test
    - Experimental (“unofficial”) scores on Complex Reasoning Test
    - Computational Thinking marker test scores
- Any feedback or suggestions on future research ideas?
  - Criterion-related validity research with military samples to validate CompT scores against performance-based criteria (e.g., training success; job performance)
    - Leverage ASVAB training relevance survey results to identify military occupations with high relevance for computational thinking and evaluate inclusion of CompT score(s) in classification composites

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Thank you!

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