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HumRRO
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The Content Alignment between the NAEP and WorkKeys Assessments

Final Report

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Executive Summary

The National Assessment Governing Board (Governing Board), which sets policy and provides general oversight and direction for the National Assessment of Educational Progress (NAEP), is conducting a program of research to determine the feasibility of using NAEP to report on the preparedness of U.S. 12th grade students for entry into postsecondary education and job training.

The purpose of the current study is to explore the relationships between the NAEP Frameworks and item pools (for mathematics and reading) and the WorkKeys assessments for: Applied Mathematics, Applied Technology, Reading for Information, and Locating Information. This study expands upon prior research on the content alignment between NAEP and WorkKeys in three major ways (ACT, 2010a; 2010b). First, this study includes the Frameworks and items from the NAEP grade 8 assessments in order to address concerns raised that grade 8 Frameworks may provide a better match to the academic content expectations of job training programs (Kilpatrick, 2012; Loomis, 2012). Second, additional WorkKeys assessments (Applied Technology and Locating Information) are included in the study to determine the extent to which NAEP mathematics and informational reading content may relate to other WorkKeys assessments. Finally, the NAEP Frameworks are directly compared to the WorkKeys targets to determine the degree of overlap between the two content domains.

Several key results do not support the use of NAEP for determinations related to the academic preparedness of U.S. 12th grade students for entry into job training:

- NAEP items do not adequately represent the WorkKeys content domain, as evidenced by the percentages of WorkKeys' mathematics and reading targets (52% and 72%, respectively) that were not matched to any NAEP item.
- Sixteen of the 24 content strands within the NAEP Math Framework and one of the three cognitive targets within the NAEP Reading Framework were not matched to any WorkKeys item.
- A direct comparison of the content domains for the two assessments indicated that the majority of the elements of the NAEP Math Framework, WorkKeys math targets, and WorkKeys applied technology targets reflected unique content.

These results are not all that surprising given the differing purposes of the two assessments. While NAEP has been designed to provide evidence of what students in the United States know and can do in a broad academic sense, WorkKeys assessments provide information about job-related skills that can be used in the selection, hiring, training, and development of employees. It should be noted that while this study found that much of the content assessed by WorkKeys and NAEP did not overlap, lack of overlap is not evaluative of either assessment. The lack of overlap in content likely reflects substantial differences in purpose and design. Both assessments may function very well for their specified purposes without exhibiting great similarity in the content they measure. .

Finally, while there is some indication that there is more overlap between grade 8 NAEP items and WorkKeys targets, which is consistent with information provided in related research studies (Loomis, 2012; Sinclair, Becker, McCloy, & Thacker, 2014; Educational Policy Improvement

Center, 2013), the results of this study suggest that including grade 8 NAEP does not improve the level of alignment between NAEP and WorkKeys, nor would the 8th grade NAEP assessments be an appropriate measure of academic preparedness for job training.

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Chapter 1: Introduction

Background[1]

The National Assessment Governing Board (Governing Board), which sets policy and provides general oversight and direction for the National Assessment of Educational Progress (NAEP), is conducting a program of research to determine the feasibility of using NAEP to report on the preparedness of U.S. 12th grade students for entry into postsecondary education and job training. The deliberations leading to the12th Grade NAEP Preparedness Research Program were set in motion in 2002 when the Governing Board established the National Commission on NAEP 12th grade Assessment and Reporting. This Blue-Ribbon Panel was charged to review the National Assessment of Educational Progress (NAEP) at grade 12 and recommend improvements. In 2004, the panel made five recommendations, including that NAEP be transformed to measure the preparedness of 12th graders for college and careers. The panel's rationale was that:

1. Grade 12 is a transition point for most students to postsecondary education, training, the military and the workforce;
2. for national security and economic viability, it is important for the U.S. to have an indicator for 12th grade student achievement;
3. NAEP is trusted for its quality and integrity; and
4. as the only source of nationally representative data on 12th grade student achievement, NAEP is uniquely positioned to serve as a preparedness indicator.

In 2007, the Technical Panel on 12th Grade Preparedness Research was formed to assist the Governing Board in planning research and validity studies to support inferences about NAEP as an indicator of academic preparedness for college and job training. There was no single, generally accepted definition of "preparedness" to guide the research agenda. Therefore, a working definition was needed to design and conduct the NAEP research. As such, the Technical Panel defined preparedness as a subset of readiness[2]. *Readiness* includes characteristics that are commonly referred to as "noncognitive factors"—factors such as motivation, persistence, conscientiousness, and interpersonal skills—which are important to achievement, but which NAEP does not purport to measure. Therefore, for the purposes of the NAEP Preparedness Research Program, *preparedness* was defined as the academic knowledge and skill levels in reading and mathematics necessary to be qualified for placement into a job training program or into a credit-bearing entry-level general education course that fulfills requirements toward a four-year degree or two-year transfer degree at a postsecondary institution (National Assessment Governing Board, 2009). According to this definition and to the guidance provided by the Technical Panel, preparedness does *not* mean success in postsecondary education and training. It refers only to being qualified to enter into postsecondary education and training.

[1] Background section of this report originally represented in Sinclair, Becker, McCloy, & Thacker, 2014.
[2] The Technical Panel relied on the prior discussions from the National Commission on NAEP 12th Grade Assessment and Reporting in 2004, and the 2006 work of the Board's *Ad Hoc* Committee on Planning for NAEP 12th Grade Assessments to develop a working definition of preparedness.

The Technical Panel recommended a multi-method approach to the research, using a variety of studies, which, taken together, would provide evidence to support statements about preparedness for postsecondary education and job training based on NAEP performance. The five recommended types of research are:

- **content alignment studies** between NAEP and widely used examinations for college admissions, post-secondary course placement, and workplace skills;
- **statistical relationship studies** that describe how performance on NAEP relates to other relevant tests and postsecondary outcomes;
- **a higher education survey** of the tests and cut scores used for remedial course placement determinations at two-year and four-year colleges;
- **judgmental standard setting** by panels of experts in content needed for college and job training to determine the NAEP scores that represent the knowledge and skills needed to qualify for job training programs or for entry-level college credit courses without remediation; and
- **benchmarking studies** in which NAEP assessments are given to reference groups of interest, such as college freshmen or individuals entering job training programs.

In the Governing Board's 12th Grade NAEP Preparedness Research Program, the findings from studies adopting these methods are used as validity evidence to evaluate claims about 12th grade NAEP as an indicator of preparedness for postsecondary education and job training. By looking across findings from a range of study types, this program of research also enables the Governing Board to evaluate the degree to which the results are mutually confirming or disconfirming. Considerably more studies have been conducted investigating 12th grade NAEP as an indicator of college preparedness than studies investigating 12th grade NAEP as an indicator of job preparedness. In fact, sufficient mutually confirming evidence has been collected on studies of 12th grade NAEP as an indicator of college preparedness to support the development of a validity argument regarding supportable claims about academic preparedness for college in relation to performance on 12th grade NAEP (Fields, 2013; 2014). The research studies on academic preparedness for job training are fewer and less supportive of claims regarding 12th grade NAEP as an indicator of possessing the academic knowledge and skill levels in reading and mathematics necessary to be qualified for placement into a job training program. In the section that follows, we provide a brief overview of the inferences supported by evidence collected on 12th grade NAEP as an indicator of college preparedness, and we briefly summarize findings from three studies investigating 12th grade NAEP as an indicator of job training preparedness.

Brief Overview of Prior Research Studies

Studies Focusing on College Preparedness

To date, more than 30 studies have been conducted using one of the five study design methods. Findings from the studies focusing on college preparedness were recently synthesized into a validity argument addressing evidence in support of statements related to academic preparedness for college (Fields, 2014). Findings were largely consistent across studies and, for reading, support the inference that the percentage of students scoring at or above a score of 302 on the grade 12 NAEP reading scale is a plausible estimate of the

percentage of students who possess the knowledge, skills, and abilities in reading that would make them academically prepared for college. For mathematics, findings support the inference that the percentage of students scoring at or above 163 on the grade 12 NAEP mathematics scale is a plausible estimate of the percentage of students who possess the knowledge, skills and abilities in mathematics that would make them academically prepared for college (Fields, 2014, pgs. 10 -11).

Studies Focusing on Job Training Preparedness

Compared to the number of studies conducted to investigate NAEP as an indicator of academic preparedness for college, various feasibility issues have caused there to be far fewer studies investigating NAEP as an indicator or of academic preparedness for job training, and the findings from these few studies have been less conclusive.

Content Alignment Study between Grade 12 NAEP and WorkKeys®. A content alignment study between 12th grade NAEP and WorkKeys (used to assess job-related skills) found some similarities between NAEP and WorkKeys, but also identified significant differences in both focus and depth (ACT, 2010a; 2010b). The findings indicated that NAEP measures math and reading content more broadly and deeply than the WorkKeys assessments, which are primarily emphasize workplace skills.

Judgmental Standard Setting Study. A judgmental standard setting (JSS) study was conducted in an effort to identify NAEP scale scores at 12th grade representing the knowledge and skills in reading and mathematics needed to qualify for entry into job training programs for five exemplar occupations (Automotive Master Technician; Computer Support Specialist; Heating, Ventilation, and Air Conditioning; Licensed Practical and Licensed Vocational Nurse; and Pharmacy Technician). The findings from the JSS study did not produce supportable conclusions about where to set reference points on the NAEP scale to denote the minimum academic knowledge and skills needed for entering job training for the targeted occupations. Rather, there was significant variability in the cut scores set by replicate panels within and across occupations (Loomis, 2012; WestEd & Measured Progress, 2011; 2012).

One challenge encountered during the JSS study involved difficulty with developing agreed-upon borderline performance descriptions (BPDs) of the academic knowledge, skills, and abilities (KSAs) needed to be minimally prepared to enter job training programs (Kilpatrick, 2012). Panelists had difficulty understanding the academic language (particularly for mathematics) contained within the NAEP Frameworks. Furthermore, the lack of a common set of expectations for requirements for placement into job training programs also contributed to the panelists' difficulty with developing reasonable BPDs (Kilpatrick, 2012). Another major challenge encountered during the JSS study is that panelists identified many grade 12 NAEP items as "irrelevant" to their respective job training programs. Some panelists suggested that grade 8 NAEP would have been a better match to the requirements of their job training programs (Loomis, 2012).

As a result of these challenges, a primary conclusion from the JSS study was that additional research was needed to determine the prerequisite KSAs in reading and mathematics needed to qualify for entry into job training programs. This led to a third study (a course content analysis) to identify the prerequisite KSAs evident in course materials for entry-level job training courses (WestEd & Educational Policy Improvement Center, 2011; 2012).

Course Content Analysis Study. For this study, the NAEP reading and mathematics Frameworks were used to identify a foundational set of KSAs, which are the "objectives" in the NAEP Reading and Mathematics Framework documents. The NAEP objectives occupy the lowest level in the organizational structure of the Frameworks. Teams of mathematics and reading content experts and occupational course instructors collaborated to analyze course artifacts (e.g., syllabi, textbooks, assignments) for job training programs for the five target occupations to identify which of the NAEP objectives were evidenced in the course artifacts. The findings from this study indicate that the reading and mathematics content identified in the course artifacts are largely included in the grade 12 NAEP Frameworks, but that the content of the NAEP Frameworks are much broader (similar to what was found in the content alignment study between NAEP and WorkKeys). The course artifacts revealed that few NAEP objectives are covered in the job training programs.

In particular, for mathematics, the largest numbers of NAEP mathematics objectives (across all training programs) were found for the Number Properties and Operations domain. None of the course artifacts showed evidence of covering NAEP objectives in the Data Analysis, Statistics, and Probability domains. Moreover, although this study did not explicitly investigate the NAEP grade 8 objectives and items, the NAEP experts noticed that when "exclusions" (i.e., content irrelevant to the job training program) were removed from the grade 12 mathematics objectives, much of the complex mathematics knowledge and skills that differentiate the grade 8 objectives from the grade 12 objectives disappeared. This led the report authors to suggest that the grade 8 mathematics objectives might better describe the KSAs covered in job training course materials than the grade 12 objectives. Also, between 83 and 101 of the 130 grade 12 mathematics objectives were not evident in any of the course materials across the five target occupations.

For reading, only the NAEP reading objectives related to reading informational texts were evidenced in course artifacts. There was no evidence of NAEP reading objectives related to literary texts in the course artifacts. Of the three cognitive targets pertaining to informational text (i.e., Locate/Recall, Integrate/Interpret, and Critique/Evaluate), the most evidence was found for the Locate/Recall target and the least evidence was for the Critique/Evaluate target in the course artifacts. Moreover, the number of reading objectives not evident in any of the course materials across the five target occupations ranged between 6 and 25 of the 37 objectives.

Purpose of the Current Study

The purpose of the current study is to further explore the relations between the NAEP Frameworks and item pools and the WorkKeys assessments. NAEP is the largest nationally representative and ongoing assessment of what America's students in grades 4, 8 and 12 know and can do in various subject areas. WorkKeys assessments are designed to measure job skills, and are frequently used as a measure of job training and overall work readiness. This study expands upon prior research on the content alignment between NAEP and WorkKeys in three major ways. First, this study includes the Frameworks and items from the NAEP grade 8 assessment in order to address concerns raised that the grade 8 Frameworks may provide a better match to the minimal academic requirements of a range of job training programs (Kilpatrick, 2012; Loomis, 2012). Second, additional WorkKeys assessments (Applied Technology and Locating Information) are included in the study to determine the extent to which mathematics and informational reading content may relate to other WorkKeys assessments. Finally, the NAEP Frameworks are directly compared to the WorkKeys targets to determine the degree of overlap between the two content domains.

This study will help to identify (a) the extent to which NAEP assessments measure the content and cognitive complexity reflected in the WorkKeys targets, (b) the extent to which WorkKeys assessments measure the content and cognitive complexity reflected in the NAEP Mathematics Framework and the informational component of the NAEP Reading Framework, and (c) the amount of overlap between the NAEP Frameworks for mathematics and informational reading and the WorkKeys targets for Applied Mathematics, Applied Technology, Locating Information, and Reading for Information. Specifically, the following comparisons will be made:

- NAEP Mathematics Framework and WorkKeys targets for Applied Mathematics
- NAEP Mathematics Framework and WorkKeys targets for Applied Technology
- NAEP Reading Framework (Informational component only) and WorkKeys targets for Reading for Information
- NAEP Reading Framework (Informational component only) and WorkKeys targets for Locating Information

A discussion of the general alignment approach and a description of the steps involved in carrying out the study are presented in the Methods chapter.

Chapter 2: Method

This chapter first describes the general approach used and then describes in detail the steps taken to conduct the study.

General Approach

HumRRO's approach for the present study deviated from the NAEP content alignment design guidance (see Webb, 2005) by not requiring expert panelists to verify the alignment between each assessment and its related content standards (i.e., NAEP items to NAEP Frameworks and WorkKeys items to WorkKeys targets), and by analyzing Frameworks/targets and test items in terms of Cognitive Complexity Level (CCL) rather than in terms of Depth of Knowledge (DOK). The reasons for this modified approach are discussed below.

Content alignment studies are typically undertaken to compare assessments that have been designed to measure similar content domains. NAEP assessments, state assessments, and assessments such as SAT and ACT can all be considered tests of a content domain that relates to the overall academic preparation of students. While there may be differences in the specific content identified for each assessment system, we would expect there to be a considerable amount of overlap. As such, a comparison of the assessments relative to each set of identified content would be important for establishing that the two assessments measure the larger content domain in similar ways. WorkKeys assessments, on the other hand, are designed to measure a very specific subset of content that focuses on skills required in the workplace. We would not expect as much overlap between the NAEP and WorkKeys assessments, and would risk producing misleading results about either assessment by reporting statistics associated with the more traditional alignment approach. For example, it would not be surprising if WorkKeys items were found to link to a smaller percentage of NAEP subtopics (i.e., exhibit a narrow band on Webb's range-of-knowledge) than were a comparison set of NAEP items, given that WorkKeys intentionally targets a very specific set of workplace-related content. Producing statistics to quantify differences such as range-of-knowledge would not be particularly useful, and could potentially be misused. The present study therefore focused on mapping items to the comparison Frameworks/targets only, and added a step to directly compare the Frameworks and targets.

Alignment studies frequently employ Webb's Depth of Knowledge (DOK; Webb, 1999) levels when evaluating the alignment between the cognitive complexity expectations of assessment items and their associated content domains. Webb defined four DOK levels that can be generally described as recall, skill/concept, strategic thinking, and extended thinking. Similar to DOK levels, NAEP items are developed to reflect multiple types of mental processing that students must engage in to demonstrate performance. NAEP informational reading items are designed to capture three major reading processes reflecting increasing levels of complexity in cognitive demands: locate and recall, integrate and interpret, and critique and evaluate. Similarly, the NAEP Math Framework describes three increasingly complex levels of thinking (low, moderate, and high) that are used to classify the cognitive demands of NAEP math items.

Because NAEP assessments are built around its own well-defined cognitive complexity levels (CCLs), the decision was made to use CCLs rather than DOK levels when evaluating the cognitive demands of content domains and assessment items for the present study. Although this limits the direct comparability of this study to previous alignment studies that used DOK (ACT, 2010a; 2010b), it organizes results in a way that is more easily interpretable within the

NAEP system. Appendix C summarizes the similarities and differences between Webb's DOK levels and the NAEP CCLs.

NAEP Frameworks for both mathematics and reading are presented as a matrix and thus require reorganizing into a more familiar format to facilitate ratings by panelists. Specifically, the Frameworks were reformatted into an outline based on increasing levels of specificity. At the broadest level was the standard (e.g., Locate/Recall, Number Properties and Operations), followed by a subtopic (e.g., Number Sense), and finally the content objective. Each content objective was given a unique identifying code that panelists could use to link items to content. It is important to note that the present study included only the informational test subtopic from the Reading Framework, as prior research has indicated that NAEP objectives for literary texts are not relevant to job preparedness training (Educational Policy Improvement Center, 2013; Sinclair, et al., 2014).

The three broad standard levels of the informational component of the NAEP Reading Framework (Locate/Recall, Integrate/Interpret, Critique/Evaluate) also reflect three increasing levels of cognitive complexity. Because the cognitive complexity was implicit in the organization of the informational reading content, it was not necessary for panelists to provide CCL ratings for the informational component of the NAEP Reading Framework. Rather, panelists were asked to confirm the CCL under which each content objective within the informational component of the NAEP Reading Framework had been placed. The organization of the NAEP Math Framework did not include similarly implicit CCL ratings, so panelists were required to make these ratings.

The major tasks of this study were thus to rate or confirm the cognitive complexity of the content Frameworks/targets and assessment items, link the assessment items to the content of the comparison assessment and rate the quality of that link, and compare the NAEP Frameworks to the WorkKeys targets. Table 1 presents the specific alignment tasks included in this study, organized into four separate groups of tasks that guided the structure of the alignment workshops. The next section provides more detail about how these tasks were carried out.

Table 1. Organization of Alignment Study Tasks

Group	Mathematics	Informational Reading
A	Rate CCL of NAEP Framework Rate CCL of WorkKeys items Link WorkKeys items to NAEP Framework Compare NAEP Framework and WorkKeys targets	Confirm CCL of NAEP Framework Rate CCL of WorkKeys items Link WorkKeys items to NAEP Framework Compare NAEP Framework and WorkKeys targets
B	Rate CCL of WorkKeys targets Confirm CCL of NAEP items Link NAEP items to WorkKeys targets Compare NAEP Framework and WorkKeys targets	Rate CCL of WorkKeys targets Confirm CCL of NAEP items Link NAEP items to WorkKeys targets Compare NAEP Framework and WorkKeys targets

Note. Originally, only one group from each content area conducted comparison of the Framework to targets. Following the first workshop, it was determined that there was sufficient time for all groups to conduct that task.

Alignment Process Steps

This section discusses in detail the steps taken to complete the study. These steps include the recruitment of panelists, preparation of materials, training of workshop facilitators, conducting the workshops, and compiling workshop data for analysis.

Recruitment of Panelists

The recruitment process began with a previously created list of teachers and state level content experts from prior alignment studies who initially indicated that they would be willing to participate in the study (collected during the proposal phase of this project). HumRRO first contacted these individuals and confirmed participation of those who had not since taken on other commitments. Additional content experts were recruited by contacting NAEP State Coordinators to request recommendations and contact information of highly qualified teachers and content or curriculum specialists. Based on these recommendations, panel candidates were contacted to inquire about their interest and availability. In an effort to ensure availability of high-quality panelists, this recruitment process began while the scheduling of the workshops and other logistical issues were still being planned. The rationale for such an approach was that high-quality teachers and content specialists are in demand for other state level research opportunities during the summer months. Potential panelists who initially expressed interest were provided regular updates through the workshop schedule finalization process, making travel arrangements, and arrival at the workshop. The 48 participating panelists represented 13 different states and worked in education an average of 21 years. There was a mix of classroom teachers, department chairs, curriculum administrators, and adjunct professors and over 80% had advanced degrees. A particularly notable characteristic of the panelists is that collectively they have participated in over 160 state level special studies that include, but are not limited to: pacing guides, standards setting, alignment, item writing, curriculum, and content review.

Preparation of Materials

A number of materials were required for both the training of workshop facilitators and the workshops themselves. The types of materials, along with their creation process and any associated security measures are discussed below.

Frameworks/Targets

As described above, the NAEP Frameworks were reorganized into a format similar to the more common content standards layout of: standards, subtopics, and objectives. Similarly, WorkKeys targets documents were created based on information from the following: WorkKeys Applied Mathematics Targets for Instruction, WorkKeys Applied Technology Targets for Instruction, WorkKeys Reading for Information Targets for Instruction, and WorkKeys Locating Information Targets for Instruction.

The WorkKeys Targets for Instruction contain a series of between 3-7 skill levels, each accompanied by several bullet points identifying specific instructional targets. Rather than standard and subtopic headings, WorkKeys targets used the skill levels as the broadest category, with each bullet point being treated as a separate objective. All Framework/targets documents were created in Microsoft Excel®. More information about the layout of these documents is provided in the rating form descriptions below, and the full sets of Frameworks and targets presented to panelists are included in Appendix B. Hardcopies of the Frameworks/targets were provided to panelists for reference, and each objective from these

documents was enlarged and printed for use in the NAEP Frameworks to WorkKeys targets comparison task.

Test Items

HumRRO received permission from the National Center for Education Statistics (NCES) and ACT to access the test items used in the study via a secure FTP site. These included Adobe Acrobat® files containing the 2013 NAEP operational items for grades 8 and 12 mathematics (344 items) and informational reading (139 items), as well as a single 2013 operational form for each of the WorkKeys tests: Applied Mathematics (33 items), Applied Technology (34 items), Locating Information (38 items), and Reading for Information (33 items).

The NAEP grade 8 and 12 mathematics items were combined and randomly ordered, and information on item grade level was redacted. Items were then organized by content strand, with all items measuring Number Properties and Operations presented in a single section, followed by Measurement, Geometry, Data Analysis, Statistics and Probability, and Algebra items. Informational reading items were similarly organized, but with grade level information redacted from both items and their associated passages. Grade 8 and 12 passages were then combined and randomly ordered. Since they were provided as intact test forms, no reorganization was required for WorkKeys items.

Test Security

HumRRO has always maintained a high regard for the security of data, electronic or paper-based sensitive documents, and personally identifying information (PII). Strict policies are in place and adherence checked regularly. HumRRO approached security for this project in the following ways:

1. After receiving permission from NCES and ACT to access the test items, the transfer was completed electronically using a secure FTP site.
2. All test item electronic files were maintained on the secure HumRRO PII server.
3. Item packets were printed and photocopied in either the HumRRO Louisville or Alexandria offices for the respective alignment workshops.
4. Photocopies were inserted into binders and then stored in a locked storage room when not in use.
5. Panelists were required to sign in and out test items used during the workshops and were not left unattended by HumRRO staff.
6. After the workshops were completed, the item copies were transferred to the secure storage room designated for shredding.

Finally, HumRRO staff and all panelists completed a non-disclosure agreement which they were required to sign and return prior to participating in the study. During the initial training at the start of both workshops panelists were reminded that they had signed confidentiality agreements, that the items they were reviewing are fully operational, and that they were not permitted to discuss any item with anyone outside of the HumRRO facilitators or panelists within their group.

Rating Forms

Following the creation of item binders, rating forms were developed in Microsoft Excel®. Separate forms were created for Frameworks/targets and items. Framework/Target rating forms included the standard, subtopic, and content objective information, along with a HumRRO-created ID number. A final column contained a dropdown menu so that panelists could select the CCL rating for each NAEP objective or WorkKeys target. Figures 1 and 2 present portions of a NAEP Framework and WorkKeys target rating form.

Standard	Subtopic	HumRRO ID	Objective	CCL Rating
Number properties and operations	Number Sense	NS.a	a) Use place value to model and describe integers and decimals.	
Number properties and operations	Number Sense	NS.b	b) Model or describe rational numbers or numerical relationships using number lines and diagrams.	
Number properties and operations	Number Sense	NS.c	c) Write or rename rational numbers.	
Number properties and operations	Number Sense	NS.d	d) Recognize, translate or apply multiple representations of rational numbers (fractions, decimals, and percents) in meaningful contexts.	
Number properties and operations	Number Sense	NS.e	e) Express or interpret numbers using scientific notation from real-life contexts.	
Number properties and operations	Number sense	NS.f	f) Represent, interpret, or compare expressions for real numbers, including expressions using exponents and logarithms.	

Figure 1. Portion of NAEP Mathematics Framework rating sheet.

Level	WorkKeys Reading Target	HumRRO ID	Cognitive Complexity Rating
3	1. Pick out the main ideas and clearly stated details	WKR.3.1	
	2. Choose the correct meaning of a word when the word is clearly defined in the reading	WKR.3.2	
	3. Choose the correct meaning of common everyday and workplace words	WKR.3.3	
	4. Choose when to perform each step in a short series of steps	WKR.3.4	
	5. Apply instructions to a situation that is the same as the one they are reading about	WKR.3.5	
4	1. Identify important details that may not be clearly stated	WKR.4.1	
	2. Use the reading material to figure out the meaning of words that are not defined for them	WKR.4.2	
	3. Apply instructions with several steps to a situation that is the same as the situation in the reading materials	WKR.4.3	

Figure 2. Portion of WorkKeys reading targets rating sheet.

Item rating forms were organized to mirror the sequence of items in the item binders. Although NAEP items were accompanied by unique item IDs, an item sequence number was assigned to each item after the items had been blinded and sorted. This item number was then written on

the corresponding pages of the item binders to facilitate locating the correct item for ratings. WorkKeys item numbers were simply the item sequence number from the original test form.

Next, columns were created for confirming or rating the item CCL. NAEP informational reading and mathematics items were already assigned a CCL, so panelists were prompted to indicate only if they did not agree with the assigned value. If they indicated disagreement, they were then prompted to enter into the next column the CCL rating they believed to be more accurate. For WorkKeys items, panelists were prompted to assign a CCL. We should note that numeric values of 1, 2, 3 were used to represent the CCLs on NAEP data entry rating forms for both math and informational reading to reduce steps when analyzing the data later.

Additional explanation of the rating process will be provided in the section describing how the workshops were conducted. Figures 3 and 4 present portions of NAEP and WorkKeys item rating forms.

NAEP Reading Item Review							
Item Number	Item ID	Cognitive Complexity Level (CCL)	If you DON'T agree with assigned CCL	Alternate CCL Explanation	Link to WorkKeys Target	Quality of Link	Explanation
		1 - Locate/Recall 2 - Integrate/Interpret 3 - Critique/Evaluate	Enter alternative CCL 1- Locate/Recall 2- Integrate/Interpret 3- Critique/Evaluate	If you provided an alternate CCL, state specifically why	Enter the primary WorkKeys Target that the NAEP item measures	1 - Partially linked 2 - Fully linked	If no Target is identified or if rated partially linked, describe what content the item measures that is not part of the target. You may provide additional Targets, if necessary.
1	VE454155	2					
2	VE454157	2					
3	VE454161	2					
4	VE454163	2					
5	VE454172	2					
6	VE454175	2					

Figure 3. Portion of NAEP informational reading item rating sheet.

Item Number	Rate Cognitive Complexity Level (CCL)	Link to NAEP Frameworks	Quality of Link	Explanation
	1 - Low 2 - Medium 3 - High	Enter the primary NAEP Framework ID that the WorkKeys item measures	1 - Partially linked 2 - Fully linked	If no Framework is identified or if rated partially linked, describe what content the item measures that is not part of the Framework. You may provide additional Frameworks, if necessary.
1				
2				
3				
4				
5				
6				
7				

Figure 4. Portion of WorkKeys mathematics item rating sheet.

Supplemental Materials

In addition to paper copies of the Frameworks/targets and the electronic rating forms, several additional supplemental materials were created to facilitate the workshop processes. These included detailed facilitator and panelist instructions, detailed descriptions of the CCLs, additional information on the WorkKeys skill levels, and publicly-available sample NAEP and WorkKeys items. All applicable supplemental materials were printed and organized into folders provided to each panelist at the outset of the workshop.

Training of Workshop Facilitators

Although experienced HumRRO staff served as facilitators for the alignment workshops, two training sessions were conducted to familiarize staff with the specifics of the alignment approach used in this study. The training provided facilitators an opportunity to review the materials and processes, becoming calibrated on the application of the CCL and quality of link rating scales. The first training was conducted in the Louisville office for the facilitators of the first workshop, and the second training was conducted via teleconference for the facilitators of the second workshop. Both training sessions were conducted by the same trainer using the same training materials to help ensure calibration of the facilitators across the two workshops.

After receiving an overview of the study background and purpose, facilitators reviewed the layout of the NAEP Frameworks and WorkKeys targets and discussed their content and organization. Next, facilitators were trained on the CCLs for reading and math. This included discussions of the cognitive complexity construct and the more traditionally used DOK levels, and an orientation to the 3-point scale that would be used in the present study. Publicly-available sample NAEP items at each CCL were used to facilitate discussion. Figure 5 presents an excerpt from the training slides that illustrates the CCL ratings that panelists would be using to rate Frameworks/targets and items.

Reading	Math
Locate/Recall – explicit in text	Low – perform mechanically
Integrate/Interpret – complex inferences	Medium – joins concepts w/process
Critique/Evaluate – consider critically	High – justify math argument

Figure 5. CCL values used in rating frameworks/targets and items.

Next facilitators were led through the specific steps of the alignment process using their facilitator instruction document. This included a review of the different sets of tasks for each of the four groups at the workshops, a discussion of best practices for assisting panelists in reaching consensus and in making independent ratings, and a demonstration of the NAEP Frameworks and WorkKeys targets matching task. Facilitators were able to access the electronic rating files and other materials to familiarize themselves with the rating tasks as panelists would experience them. Facilitators discussed at length the criteria for rating an item as fully linked or partially linked and reached consensus on what guidance to provide panelists. 'Partially linked' items were those in which some part of the item measured content that was not part of the identified primary standard. 'Fully linked' items were those in which all of the content measured by the item was contained in the identified primary standard.

Conducting Alignment Workshops

Each workshop consisted of the following series of tasks:

- General training session
  - Study background and purpose
  - Task overview

- Introduction to the NAEP Frameworks and WorkKeys targets
- Introduction of cognitive complexity levels (CCLs)

- Group specific training
  - Introductions
  - Orientation to materials and electronic rating forms

- Rating of CCL of NAEP Frameworks or WorkKeys targets
  - Calibration activity
  - Independent ratings
  - Consensus rating
    - Group came to agreement or majority rating selected
  - Collection of individual rating forms

- Rating of NAEP or WorkKeys items
  - Item binder sign out
  - Calibration activity
  - Independent ratings
  - Calibration checks
  - Item binder sign in

- Comparison of NAEP Frameworks and WorkKeys targets[3]
  - Arrangement of NAEP Frameworks on tables[4]
  - Matching of WorkKeys targets to Frameworks
    - Group consensus of exact match
  - Facilitator created electronic spreadsheet of results

- Checkout
  - Debriefing form
    - Panelists' perceptions of the overall level of alignment between the NAEP and WorkKeys assessments
    - Quality of the alignment workshop.

Compiling Workshop Data for Analysis

The workshop was organized such that electronic data files were immediately available upon completion of the workshop. Panelists pulled rating forms from panelists' laptops, created their data file for the Frameworks-to-targets matching task, and then saved all files to HumRRO's secure server. SAS software was used to import data from all Excel spreadsheets into a single data file for analysis.

The first analytical step was to compare the ratings from the two workshops in order to determine the level of agreement between raters, both within and across the two workshops. The distributions of ratings (e.g., mean numbers of items matched to content, mean numbers of items rated at each CCL) were very similar across the workshops, indicating that averaging results from corresponding tasks across the two workshops would be appropriate (see Appendix A for results separated by workshop). CCL ratings were then analyzed to determine

[3] Due to scheduling issues, only one math and one reading group conducted this task in the first workshop.
[4] Because of the large number of NAEP mathematics objectives, it was more practical for math panelists to lay out WorkKeys targets and sort the NAEP objectives among those.

the average percentages of Frameworks/targets and items at each CCL, and the percentages of items that were rated below, at, or above the CCL of the linked Framework or target. Item content ratings were next analyzed to determine the average percentage of NAEP items that were linked to a WorkKeys target and the average percentage of WorkKeys items that were linked to the NAEP Framework. Similarly, the average percentages of NAEP Frameworks that were linked to WorkKeys items and the average percentage of WorkKeys targets that were linked to NAEP Framework were calculated.

A final step involved a calculation of the average percentage of the NAEP Frameworks that were identified as exact matches to WorkKeys targets, the average percentage of WorkKeys targets that were identified as exact matches to NAEP Frameworks, and the average percentages of the Frameworks and targets that were considered to be unique.

Rather than making determinations about the degree of alignment similar to what is produced in typical alignment studies, the intent of this study was to document the amount of overlap between the content domains and items of two different assessments. No criteria for what constitutes adequate levels of alignment in this sense have been established, and directly applying criteria from more traditional alignment studies (e.g., at least six items targeting a particular element of a content domain as evidence of Webb's categorical concurrence for that content element) may not be appropriate given that the purpose of this study is not to evaluate the extent to which an item pool or test form adequately reflects the intended content domain.. Rather with the goal of quantifying the degree of alignment, data are presented in terms of the patterns of similarities and differences in the assessment content and cognitive complexity between the content domains and items of the two assessments. Chapter 3 of this report summarizes these results.

Issues

An error was made in the creation of CCL rating files and reference sheets for WorkKeys reading targets in workshop 1. This resulted in panelists not seeing two of the WorkKeys reading targets. This error was corrected for workshop 2. An investigation of this error indicated no substantial impact as neither of the initially deleted WorkKeys targets were consistently matched to NAEP items by workshop 2 panelists. We are confident that this error did not have an impact on the general findings reported herein.

Chapter 3: Results

The results from the analyses of data obtained from the alignment studies will be organized around the three major goals of this study. First, results that address the extent to which the NAEP assessments reflect both the content and the cognitive complexity level of the WorkKeys targets will be presented. Next, results that address the extent to which the WorkKeys assessments reflect both the content and the cognitive complexity level of the NAEP Frameworks will be presented. Finally, the results that address the amount of overlap between the NAEP Math Framework and the informational component of the NAEP Reading Framework and the WorkKeys targets for Applied Mathematics, Applied Technology, Locating Information, and Reading for Information will be presented.

As described in the methods section of this report, the results obtained from the two separate workshops were similar enough to warrant averaging across the two workshops. This section contains those average results. Tables containing results by workshop are included in Appendix A.

NAEP Assessments and WorkKeys Targets

This section presents the results from the tasks linking NAEP items to the WorkKeys targets. The alignment between item content and content designated in the targets is presented first, followed by the alignment of the cognitive complexity of items with that reflected in the targets.

Content Alignment

Items rated either 'partially linked' or 'fully linked' were combined to reflect that panelists saw some connection between the content domain of one assessment and the items of the comparison assessment. Because the items under review were not developed to measure the content domain to which they were being compared, the decision was made to capture the most liberal evaluation of alignment possible. A more conservative approach that included only items rated as ‘fully linked’ would have yielded lower levels of content alignment.

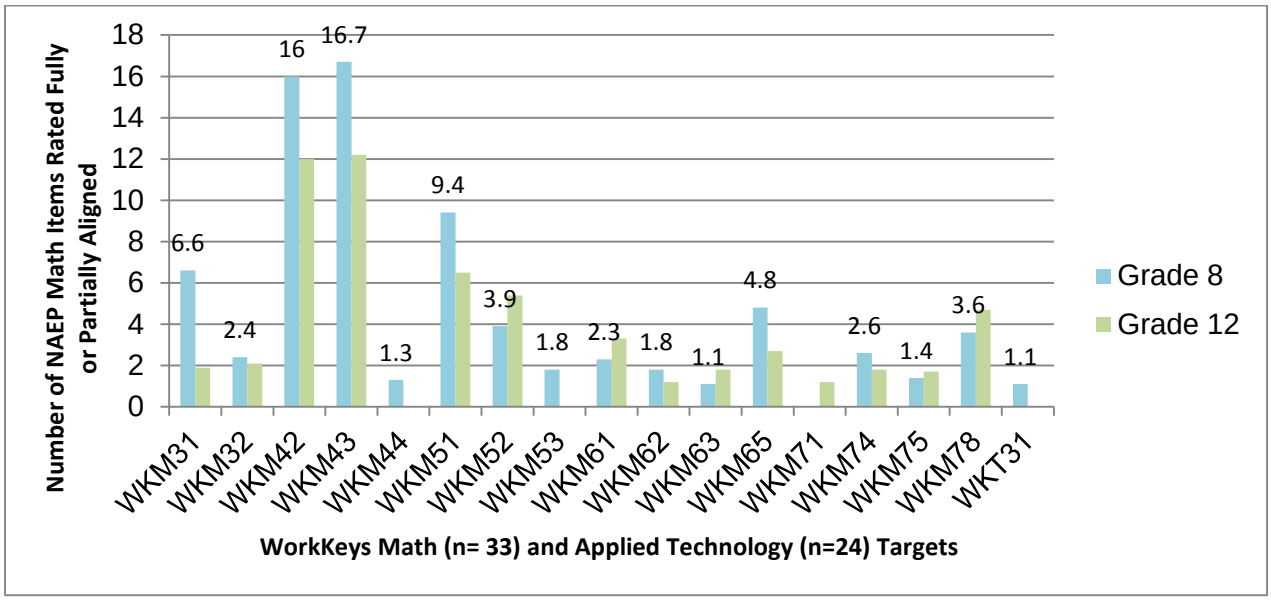
Table 2 presents the percentage of Grade 8 and Grade 12 NAEP math items that were rated as either not aligned to a WorkKeys target, or that were rated as partially or fully aligned to a WorkKeys target. Because math content specialists frequently identify different possible approaches to the same problem, agreement on the exact target was of less concern than agreement that an item did measure some content targeted by WorkKeys. Table 2 shows that a higher percentage of grade 8 than grade 12 math items was rated as partially or fully aligned to a WorkKeys target(s). However, slightly less than half of the grade 8 math items were designated as not aligned to any WorkKeys target. Among 12th grade NAEP math items, 66% were rated as not aligned to any WorkKeys target.

Table 2. Content Alignment of NAEP Math Items with WorkKeys Targets

	% Not Aligned to WorkKeys	% Partially or Fully Aligned to WorkKeys
NAEP Math Items		
Grade 12 (n= 191)	66.02%	33.98%
Grade 8 (n= 153)	46.34%	53.66%

Note. WorkKeys targets include both math (n= 33) and applied technology (n= 24).

The breadth of NAEP items aligned to WorkKeys targets (34% to 54% of grade 12 and grade 8 items, respectively) demonstrates an unsurprising degree of overlap. What is more informative is the breadth of WorkKeys targets that are measured by NAEP items and the distribution of aligned NAEP items among these targets. Figure 6 depicts the WorkKeys math and applied technology targets to which NAEP math items were identified as being partially or fully aligned. The horizontal axis of Figure 6 shows that only 16 of the 33 WorkKeys math targets, and only one of the 24 applied technology targets were identified as, on average, being aligned with at least one NAEP math item. The height of the bars shows that only a few WorkKeys targets were linked to more than two NAEP math items. For example, an average of 16 NAEP math items were rated as partially aligned to WorkKeys target 4.2 (Solve problems that require one or two operations), and an average of 17 NAEP math items were rated as partially aligned to WorkKeys target 4.3 (Figure out averages, simple ratios, simple proportions, or rates using whole numbers and decimals); however, an average of only one NAEP item was rated as measuring WorkKeys math targets 4.4 (Add commonly known fractions, decimals, or percentages), 6.3 (Calculate multiple rates), 7.1 (Solve problems that include nonlinear functions (such as rate of change) and/or that involve more than one unknown) and 7.5 (Set up and manipulate complex ratios or proportions), and WorkKeys applied technology target 3.1 (Identify how basic tools work). Finally, the blue and green bars represent grade 8 and grade 12 items, respectively, and comparing the height of the bars indicates that larger numbers of grade 8 items were rated as partially or fully aligned to the WorkKeys targets.



Note. Total number of grade 8 NAEP math items= 153. Total number of grade 12 NAEP math items= 191. Horizontal axis labels reflect HumRRO-developed IDs for the WorkKeys targets (see Appendix B).

Figure 6. Breadth of coverage of WorkKeys targets by NAEP math items.

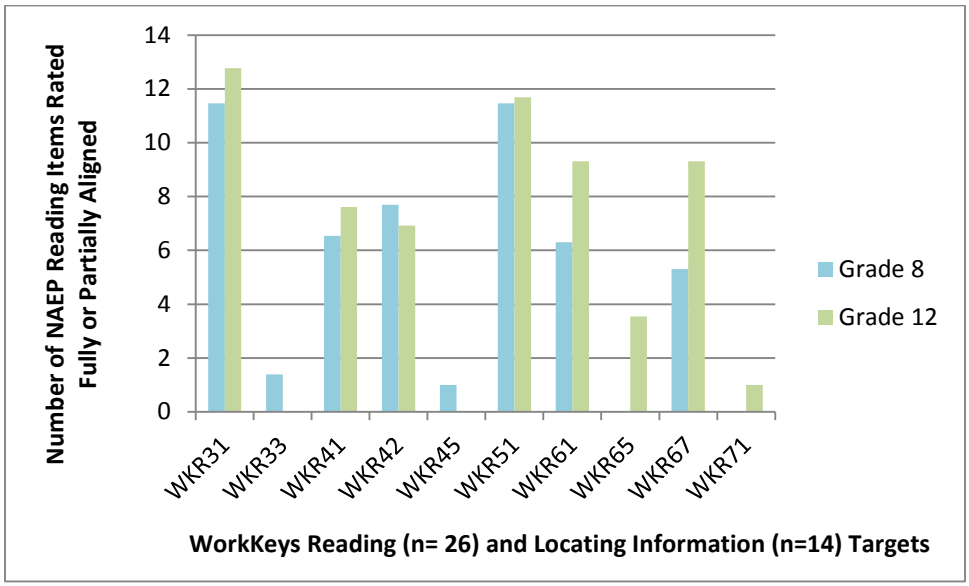
Table 3 presents the percentages of grade 8 and grade 12 NAEP informational reading items that were rated as either not aligned to a WorkKeys target or partially or fully aligned to a WorkKeys target(s). Much higher percentages of NAEP informational reading items were identified as partially or fully aligned to a WorkKeys target when compared to math items. This is likely due to the fact that while all NAEP math items were used in the review, only informational reading items were included (roughly half of the reading item pool). Grade 8 informational reading items also had slightly higher levels of alignment compared to grade 12 informational reading items.

Table 3. Content Alignment of NAEP Informational Reading Items with WorkKeys Targets

	%Not Aligned to WorkKeys	%Partially or Fully Aligned to WorkKeys
NAEP Reading Items		
Grade 12 (n= 77)	12.29%	87.71%
Grade 8 (n= 62)	7.57%	92.43%

Note. WorkKeys targets include both reading (n= 33) and locating information (n= 26).

Figure 7 depicts the WorkKeys reading targets to which NAEP informational reading items were identified as being partially or fully aligned. The horizontal axis shows that only ten of the 26 WorkKeys reading targets, and none of the 14 locating information targets, were identified as, on average, being aligned with at least one NAEP informational reading item. The WorkKeys reading target to which the largest number of informational NAEP reading items aligned was target 3.1 (Pick out the main ideas and clearly stated details). The smallest number of NAEP informational reading items aligned to WorkKeys targets 4.5 and 7.1 (Recognize cause-effect relationships and Figure out the definitions of difficult, uncommon words based on how they are used, respectively). Comparing the height of the blue and green bars indicates that somewhat larger numbers of grade 12 items were rated as partially or fully aligned to the WorkKeys targets than grade 8 items.



Note. Total number of grade 8 NAEP reading items= 62. Total number of grade 12 NAEP reading items= 77. Horizontal axis labels reflect HumRRO-developed IDs for the WorkKeys targets (see Appendix B).

Figure 7. Breadth of coverage of WorkKeys targets by NAEP informational reading items.

Cognitive Complexity Level Alignment

Another important component of assessing the alignment between assessments and content standards is to document the extent to which the assessment measures the content at the intended level of complexity. Table 4 compares the distributions of CCL ratings among the WorkKeys targets and the NAEP math items. It is important to remember that NAEP items were not developed to reflect the WorkKeys targets, so we would not necessarily expect the distributions in the table to match. What Table 4 does demonstrate is that while the WorkKeys

math and applied technology content domains were more concentrated in the middle level of cognitive complexity, the NAEP math items were more concentrated in the lower level.

Table 4. Distribution of CCL Ratings for WorkKeys Targets and NAEP Math Items

	Cognitive Complexity		
	Level 1	Level 2	Level 3
WorkKeys Targets			
Math (n= 33)	37.88%	50.00%	12.12%
Applied Technology (n= 24)	27.08%	58.33%	14.58%
NAEP Math Items			
Grade 12 (n= 191)	55.81%	39.11%	5.08%
Grade 8 (n= 153)	58.10%	38.43%	3.46%

Another way to compare the cognitive complexity of items and content targets is to calculate the percentage of items that are rated at the same, lower, or higher level of complexity as their associated target (linked in the previous task). Only those NAEP math items that were rated as partially or fully aligned to a particular WorkKeys target were included. Table 5 shows that of the grade 8 and 12 NAEP math items that were linked to a WorkKeys target, the largest percentage of items were rated at the same level of complexity as the target. This pattern was stronger among the grade 8 items (58%) than the grade 12 items (48%). The rightmost column in Table 5 indicates that roughly 25%-30% of NAEP math items across the grade levels were rated at a CCL lower than their identified WorkKeys content target.

Table 5. CCL Alignment of NAEP Math Items with WorkKeys Targets

	Items Higher than Target	Items Same as Target	Items Lower than Target
NAEP Math Items			
Grade 12 (n= 191)	21.88%	48.23%	29.89%
Grade 8 (n= 153)	17.17%	58.34%	24.48%

Note. WorkKeys targets include both math (n= 33) and applied technology (n= 24).

Table 6 presents similar distributions of CCL ratings among the WorkKeys targets and the NAEP informational reading items. Similar to math results, reading WorkKeys targets tended to be concentrated at the middle level of cognitive complexity. NAEP informational reading items had a similar pattern of concentration.

Table 6. Distribution of CCL Ratings for WorkKeys Targets and NAEP Informational Reading Items

	Cognitive Complexity		
	% Level 1	% Level 2	% Level 3
WorkKeys Targets			
Reading (n= 26)	28.00%	66.00%	6.00%
Locating Information (n= 14)	28.57%	57.14%	14.29%
NAEP Informational Reading Items			
Grade 12 (n= 77)	18.88%	63.34%	17.78%
Grade 8 (n= 62)	19.98%	61.66%	18.36%

Table 7 presents the percentage of NAEP informational reading items that were rated at the same, lower, or higher level of complexity as their associated WorkKeys target. Similar to math, the largest percentages of items at both grade levels were rated at the same level of complexity as the identified target. Approximately 20% of NAEP informational reading items at both grade levels were rated at a cognitive complexity level higher than their identified WorkKeys target.

Table 7. CCL Alignment of NAEP Informational Reading Items with WorkKeys Targets

	Items Higher than Target	Items Same as Target	Items Lower than Target
NAEP Informational Reading Items			
Grade 12 (n= 77)	18.45%	67.88%	13.67%
Grade 8 (n= 62)	21.85%	71.31%	6.84%

Note. WorkKeys targets include both reading (n= 33) and locating information (n= 26).

WorkKeys Assessments and NAEP Frameworks

This section presents the results from the tasks linking WorkKeys items to the NAEP content Frameworks. The alignment between item content and content designated in the Frameworks is presented first, followed by the alignment of the cognitive complexity of items with that reflected in the Frameworks.

Content Alignment

Table 8 presents the percentage of WorkKeys math and applied technology items that were rated as either not aligned to one or more elements of the NAEP Math Framework, or that were rated as partially or fully aligned to one or more elements of the NAEP Math Framework. Every WorkKeys math item was rated as either partially or fully aligned to one or more elements of the NAEP Math Framework. Approximately 59% of WorkKeys applied technology items were rated as partially or fully aligned to one or more elements of the NAEP Math Framework.

Table 8. Content Alignment of WorkKeys Math and Applied Technology Items with NAEP Math Framework

	% Not Aligned to the Framework	% Partially or Fully Aligned to the Framework
WorkKeys Items		
Math (n= 33)	0.00%	100.00%
Applied Technology (n=33)	40.93%	59.07%

Note. NAEP math framework includes 100 elements from grade 8 and 129 elements from grade 12.

Figure 8 depicts the elements of the NAEP Math Framework to which WorkKeys items were identified as being partially or fully aligned. The NAEP Math framework is organized around five content areas, with a total of 24 content strands within these content areas and a total of 229 content objectives (222 unique objectives across the grades and 7 that were the same for both grade 8 and 12). Although ratings were made at the content objective level, Figure 8 depicts the content strands of the NAEP Math Framework to which WorkKeys items were linked. Unlike Figures 6 and 7, the NAEP Math Framework is located on the vertical axis to allow for clear presentation of the content strand labels. Figure 8 shows that eight of the 24 NAEP math content strands were identified as being measured by at least one WorkKeys math or applied technology item. Of those eight, the number operations strand was linked to the largest number of WorkKeys items.

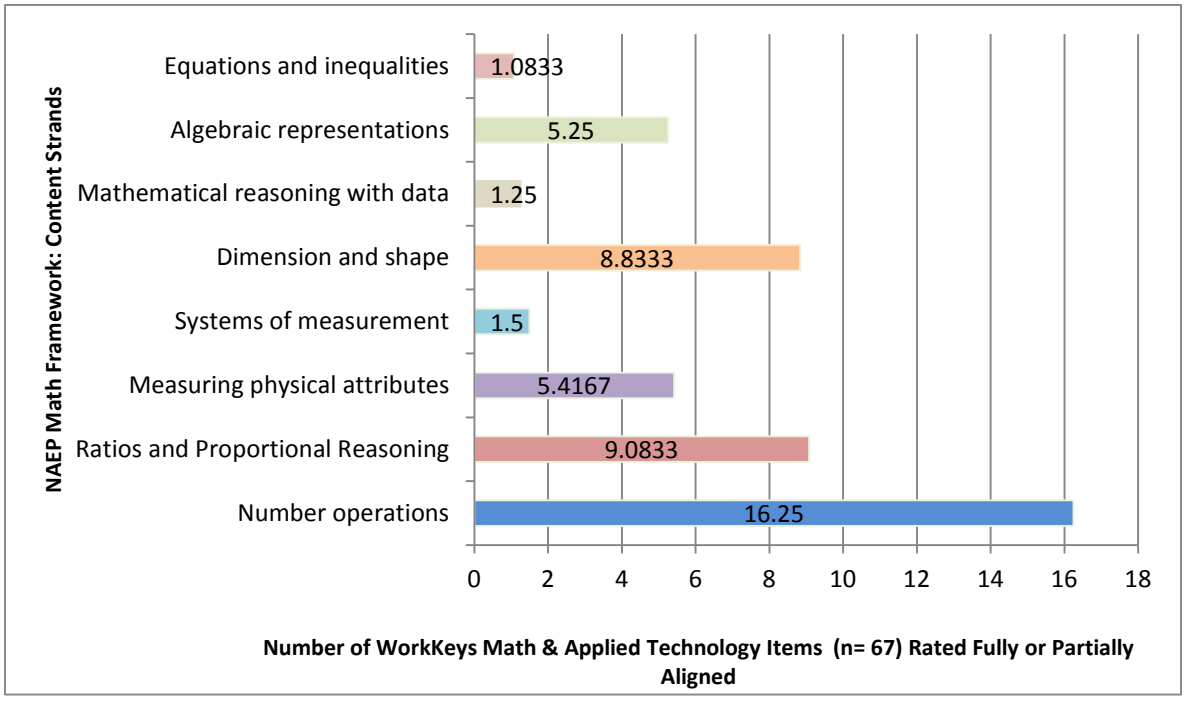


Figure 8. Breadth of coverage of NAEP Math Framework by WorkKeys items.

Table 9 presents similar results for the content alignment between the WorkKeys reading and locating information items and the informational component of the NAEP Reading framework. One hundred percent of WorkKeys reading items were rated as partially or fully aligned to an element of the informational component of the NAEP Reading Framework. Nearly all (99%) of

the WorkKeys locating information items were also rated as partially or fully aligned to an element of the informational component of the NAEP Reading Framework.

Table 9. Content Alignment of WorkKeys Reading and Locating Information Items with Informational Component of the NAEP Reading Framework

	Not Aligned to Framework	Partially or Fully Aligned to Framework
WorkKeys Items		
Reading (n= 33)	0.00%	100.00%
Locating Information (n= 38)	0.66%	99.34%

Note. NAEP reading framework includes 24 elements which are identical for grades 8 and 12.

Figure 9 depicts the elements of the informational component of the NAEP Reading Frameworks to which WorkKeys items were identified as being partially or fully aligned. Rather than content areas, the NAEP Reading Framework is organized around three cognitive targets, locate/recall, integrate/interpret, and critique/evaluate. Figure 9 shows that the largest number of WorkKeys items were linked to an element of the locate/recall cognitive target, while no WorkKeys items were linked to an element of the critique/evaluate cognitive target.

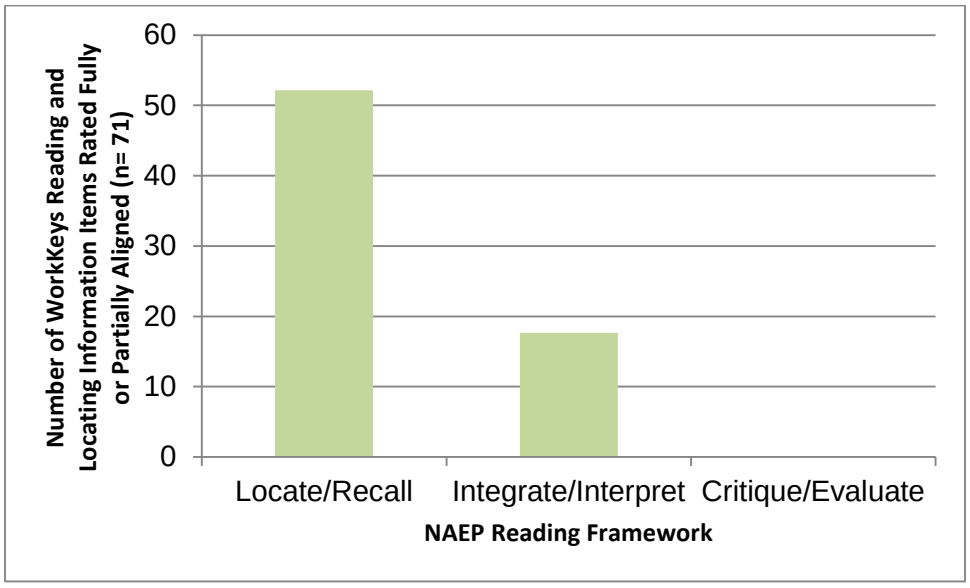


Figure 9. Breadth of coverage of the informational component of the NAEP Reading Framework by WorkKeys items.

Cognitive Complexity Level Alignment

Table 10 compares the distributions of CCL ratings among the WorkKeys items and the NAEP Math Framework. The highest percentages of the grade 8 and 12 NAEP Math Framework were rated at the middle level of cognitive complexity, whereas the highest percentages of WorkKeys math and applied technology items were rated at the lowest level of cognitive complexity. The smallest percentages of both the NAEP Math Framework and WorkKeys math and applied technology items were rated at the highest cognitive complexity level, though there were greater percentages of the NAEP Framework written at this level compared to WorkKeys items.

Table 10. Distribution of CCL Ratings for the NAEP Math Framework and WorkKeys Math and Applied Technology Items

	Cognitive Complexity		
	Level 1	Level 2	Level 3
NAEP Math Framework			
Grade 12 (n= 129)	31.01%	52.33%	16.67%
Grade 8 (n= 100)	44.00%	47.00%	9.00%
WorkKeys Items			
Math (n= 33)	60.35%	39.14%	0.51%
Applied Technology (n= 34)	58.58%	38.73%	2.70%

Table 11 presents the percentage of WorkKeys items that were rated at the same, lower, or higher level of complexity as the element of the NAEP Math Framework to which they were linked. Whereas Table 10 includes the CCL ratings for the full Math Framework and full set of WorkKeys items, Table 11 focuses on only those WorkKeys items that were matched to an element of the NAEP Math Framework. The largest percentage of WorkKeys math items were rated at the same complexity level as their associated element of the NAEP Math Framework, while the largest percentage of WorkKeys applied technology items were rated at a lower level of complexity than their associated element of the NAEP Math Framework. Taken together, Tables 10 and 11 indicate that the NAEP Math Framework tends to reflect higher levels of cognitive complexity than the pool of WorkKeys math and applied technology items, and that those WorkKeys items that were identified as measuring one or more NAEP Framework elements reflected similar or lower levels of cognitive demands as their associated element of the NAEP Framework.

Table 11. CCL Alignment of WorkKeys Math and Applied Technology Items with NAEP Math Framework

	Items Higher than Framework	Items Same as Target	Items Lower than Framework
WorkKeys Items			
Math (n= 33)	13.10%	49.62%	37.28%
Applied Technology (n= 34)	7.88%	26.14%	65.98%

Note. NAEP math framework includes 100 elements from grade 8 and 129 elements from grade 12.

Table 12 presents distributions of CCL ratings among the informational component of the NAEP Reading Frameworks and the WorkKeys reading and locating information items. The informational component of the NAEP Reading Framework was split fairly evenly across the three complexity levels. It is important to note that the NAEP informational reading frameworks are organized by cognitive targets rather than by content strands as is the case in mathematics. Because information about CCL is implicit in the organization of the Reading Framework, panelists were not expected to independently assign CCL ratings. Asking panelists to provide independent ratings could potentially yield a set of CCL levels that differ substantially from the NAEP Framework, thus requiring additional arbitration to determine which set of CCLs should be considered “correct.” Panelists were rather asked to confirm that the assigned CCL of each element of the NAEP Reading Framework was appropriate.

Table 12 indicates that the majority of WorkKeys reading and locating information items were rated by panelists at the locate/recall level of cognitive complexity. Approximately 1%-2% of WorkKeys reading and locating information items were rated at the critique/evaluate level of cognitive complexity.

Table 12. Distribution of CCL Ratings for the Informational Component of the NAEP Reading Framework and WorkKeys Reading and Locating Information Items

	Cognitive Complexity		
	Level 1	Level 2	Level 3
NAEP Informational Reading Framework			
Grades 8 & 12 (n= 24)	29.17%	37.50%	33.33%
WorkKeys Items			
Reading (n= 33)	78.54%	20.71%	0.76%
Locating Information (n= 38)	59.65%	38.60%	1.75%

Table 13 summarizes the alignment between the WorkKeys items and the informational component of the NAEP Reading Framework in terms of cognitive complexity among those WorkKeys items that were matched to the NAEP Framework. Nearly all (99%) of WorkKeys reading items that were matched to an element of the informational component of the NAEP Reading Framework were rated at the same cognitive complexity level as the associated element of the Framework. Similarly, a large majority (91%) of WorkKeys locating information items were rated at the same cognitive complexity level as their identified element of the informational component of the NAEP Reading Framework Although the cognitive complexity of the informational component of the NAEP Reading Framework as a whole tended to be higher than the pool of WorkKeys reading and locating information items, those WorkKeys items that were matched to an element of the informational component of the NAEP Reading Framework reflected similar levels of cognitive demand.

Table 13. CCL Alignment of WorkKeys Reading and Locating Information Items with NAEP Informational Reading Framework

	Items Higher than Framework	Items Same as Target	Items Lower than Framework
WorkKeys Items			
Reading (n= 33)	0.76%	98.99%	0.25%
Locating Information (n= 38)	9.05%	90.95%	0.00%

Note. NAEP reading framework includes 24 elements which are identical for grades 8 and 12.

NAEP Frameworks and WorkKeys Targets

This section presents the results from the tasks directly linking NAEP Frameworks to the WorkKeys targets. The alignment between the content knowledge and skills represented in the Frameworks and targets is presented first, followed by the level of alignment in terms of the cognitive complexity of the Frameworks and targets.

Content Alignment

A total of three groups of raters conducted this rating task (one from Workshop 1 and two from Workshop 2). Rather than quantitative ratings that could be averaged, the data from this task included consensus decisions about which elements of the NAEP Frameworks and WorkKeys targets reflected equivalent content knowledge and/or skills. Consequently, the following arbitration rules were developed to determine the final percentages of matching Frameworks and targets. If at least two or more groups agreed that an element of a NAEP Framework was linked to any WorkKeys target, then that Framework element was counted among the percentage of NAEP Frameworks that were matching. If two or more groups agreed that a WorkKeys target was linked to an element of a NAEP Framework, then that target was counted among the percentage of WorkKeys targets that were matching.

Table 14 contains the percentages of elements of the NAEP Math Framework and WorkKeys math and applied technology targets that were judged as being matched in terms of the content knowledge and skills reflected in each. Table 14 indicates that the majority of elements of the NAEP Math Frameworks were not matched to a WorkKeys target. The rate of matches was slightly higher for the NAEP grade 8 Math Framework than compared to the NAEP grade 12 Math Framework (i.e., 25% and 18%, respectively). Approximately 60% of WorkKeys math targets were considered to reflect unique content that did not match an element of the NAEP Math Framework, while all WorkKeys applied technology targets were considered unique.

Table 14. Comparison of NAEP Math Framework and WorkKeys Math and Applied Technology Targets: Percent Unique versus Matching

	% Unique	% Matching
NAEP Math Frameworks		
Grade 12 (n= 129)	85.25%	17.75%
Grade 8 (n= 100)	75.00%	25.00%
WorkKeys Targets		
Math (n= 33)	60.61%	39.39%
Applied Technology (n= 24)	100.00%	0.00%

Table 15 focuses in on the WorkKeys math targets that were linked to an element of the NAEP Math Framework. Among those 13 of the 33 math targets, over 75% were linked with an elements of the grade 8 Framework.

Table 15. Percent of Aligned WorkKeys Math Targets Linked to Each NAEP Grade Level (n=13)

	NAEP Framework	
	NAEP Grade 8	NAEP Grade 12
WorkKeys Targets		
Math	76.92%	23.08%

Table 16 presents the results from the same task using the informational component of the NAEP Reading Framework and reading and locating information targets. Table 16 shows that half of the elements of the informational component of the NAEP Reading Framework were matched to a WorkKeys target. Approximately 54% of WorkKeys reading targets were matched

with an element of the informational component of the NAEP Reading Framework. Similarly, about half of the WorkKeys locating information targets were matched to an element of the informational component of the NAEP Reading Framework.

Table 16. Comparison of NAEP Informational Reading Framework and WorkKeys Reading and Locating Information Targets: Percent Unique versus Matching

	% Unique	% Matching
NAEP Framework		
Grades 8 & 12 (n= 24)	50.00%	50.00%
WorkKeys Targets		
Reading (n= 26)	45.83%	54.17%
Locating Information (n= 14)	50.00%	50.00%

Note. Informational component of NAEP Reading Framework were identical for grades 8 and 12.

Cognitive Complexity Alignment

Table 17 presents the distribution of cognitive complexity level ratings for the NAEP Math Framework and the WorkKeys math and applied technology targets. Across the Framework and targets, the largest percentages were rated at the middle level of cognitive complexity, followed by CCL 1 and 3, respectively.

Table 17. CCL Ratings for NAEP Math Framework and WorkKeys Math and Applied Technology Targets

	CCL Level 1	CCL Level 2	CCL Level 3
NAEP Framework			
Grade 12 (n= 129)	31.01%	52.33%	16.67%
Grade 8 (n= 100)	44.00%	47.00%	9.00%
WorkKeys Targets			
Math (n= 33)	37.88%	50.00%	12.12%
Applied Technology (n= 24)	27.08%	58.33%	14.58%

Table 18 presents the distribution of cognitive complexity level ratings for the informational component of the NAEP Reading Framework and the WorkKeys reading and locating information targets. As mentioned previously, NAEP Reading Framework already contained information about cognitive complexity and so panelists were asked to review these existing CCL designations. Panelists confirmed the CCL levels designated in the NAEP Reading Framework, which are presented in Table 18.

While the elements of the informational component of the NAEP Reading Framework were more evenly split in terms of cognitive complexity, WorkKeys reading and locating information targets were more frequently rated as CCL 2. A relatively small percentage of WorkKeys reading and locating information targets were rated as CCL 3 compared to the elements of the informational component of the NAEP Reading Framework.

Table 18. CCL Ratings for NAEP Informational Reading Framework and WorkKeys Reading and Locating Information Targets

	CCL Level 1	CCL Level 2	CCL Level 3
NAEP Framework			
Grades 8 & 12 (n= 24)	29.17%	37.50%	33.33%
WorkKeys Targets			
Reading (n= 26)	28.00%	66.00%	6.00%
Locating Information (n= 14)	28.57%	57.14%	14.29%

Chapter 4: Discussion

The purpose of this study was to contribute to the body of research that seeks to determine the feasibility of using NAEP to report on the academic preparedness of U.S. 12th grade students for entry into job training. NAEP scores would be interpretable as an estimate of overall preparedness for entry into job training if the items on which those scores are based are a representative sample from the domain of items that measure the knowledge and skills considered to be indicative of preparedness.

The most straightforward way to determine if this assumption is met is to map NAEP assessment items to a content domain that has been established as reflecting these knowledge and skills. To that end, panels of content experts reviewed the NAEP item pool and identified those items that were fully or partially aligned to the content targets of the WorkKeys assessments, a nationally recognized assessment system that is used by several states to make determinations of students' career readiness. Results indicated some overlap between the NAEP math and informational reading assessment items and the associated WorkKeys content domain. NAEP items tend to reflect only a subset of the WorkKeys content. In fact, the majority of WorkKeys targets included in this study were not linked to a NAEP item. This is not all that surprising given the differing purposes of the two assessments. While NAEP has been designed to assess what students know and can do on a broad set of academic content, WorkKeys has been designed for the purpose of providing information about job-related skills. It should be noted that while this study found that much of the content assessed by WorkKeys and NAEP did not overlap, lack of overlap is not evaluative of either assessment. The lack of overlap in content likely reflects substantial differences in purpose and design. Both assessments may function very well for their specified purposes without exhibiting great similarity in the content they measure.

An additional approach to determining the appropriateness of NAEP for making decisions about job training preparedness is to essentially perform the reverse of the procedures described above. By identifying the knowledge and skills of the NAEP content domain that are being measured by WorkKeys items, it is possible to evaluate whether the items on which WorkKeys scores are based can be considered representative of the NAEP content domain. Similar to the first set of analyses, WorkKeys items were found to measure only a subset of the NAEP math and informational reading content domains. These results should be interpreted with some caution as only a single operational form for each WorkKeys assessment was available for this study. A larger pool of WorkKeys items may have yielded a higher level of representation of the NAEP content domain.

Comparisons of the cognitive complexity implied by the content domains with that of the items of the comparison assessment indicated that the largest percentages of the elements of both the NAEP Frameworks and the WorkKeys targets were categorized at the middle level of cognitive complexity (see Tables 4, 10 and 17; Tables 6, 12, and 18). By contrast, higher percentages of items on both assessments (with the exception of NAEP informational reading items) were categorized at the lowest level of cognitive complexity (see Tables 4 and 10; Tables 6 and 12). The largest percentages of math and reading items from both assessments tended to be rated at the same level of cognitive complexity as the element of the Framework/targets to which they had been aligned, with the exception of WorkKeys Applied Technology items being more frequently rated at a lower complexity than the NAEP Math framework (see Tables 5 and 11 for math; Tables 7 and 13 for reading).

Perhaps an even more straightforward approach is to directly compare the two sets of content domains. Results from these comparisons indicated that the majority of the elements of the NAEP Math Framework, WorkKeys math targets, and WorkKeys applied technology targets reflected unique content. The differences were less striking for the reading comparisons, though roughly half of the elements of the informational component of the NAEP Reading Framework, WorkKeys reading targets, and WorkKeys locating information targets were characterized as representing unique content. Analysis of the cognitive complexity levels of the Frameworks and targets indicated that the two math content domains were similar in their level of complexity, while the informational component of the NAEP Reading Framework included a higher amount of cognitively complex content expectations compared to the WorkKeys targets.

As no established criteria are available for making judgments about the adequacy of alignment between content domains and item pools developed for different assessments, this study sought to document the overlap between the content and cognitive complexity domain of one assessment and the items of a comparison assessment. The first set of results demonstrated that several elements of each content domain were not measured by any items from the comparison assessment. This provides the most pointed evidence that scores derived from the two assessments are not interchangeable in terms of the information they provide about students' knowledge, skills, and abilities.

The results from the present study are in line with prior research on the content alignment study between 12th grade NAEP and WorkKeys (ACT, 2010a; 2010b). The two assessments and their associated content domains differ in breadth and rigor, with WorkKeys focusing on knowledge and skills that are largely unrepresented within the NAEP item pool.

Taken together, these results do not support the use of NAEP for determinations related to the preparedness of U.S. 12th grade students for entry into job training. NAEP mathematics and reading items reflect broad content domains, but do not reflect the job-focused knowledge and skills that the WorkKeys content domain represents. One additional component of this study that constitutes an expansion on prior approaches to documenting the alignment between NAEP and WorkKeys is the inclusion of NAEP items and frameworks from both grades 12 and 8. While there is some indication that there is more overlap between grade 8 NAEP items and WorkKeys targets, the results from this study do not suggest hat including grade 8 NAEP improves the level of alignment between NAEP and WorkKeys, nor that the 8th grade NAEP assessments would be an appropriate measure of job training preparedness.

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Appendix A: Analyses by Workshop

Table A1. Average Number of NAEP Items Linked to a WorkKeys Target

Workshop	Subject	Grade	# Reviewers	# Items Matched Mean	# Items Matched SD	Total Item N
1	Math	12	5	69.2	3.49	191
2	Math	12	5	60.6	10.33	191
1	Math	8	5	86.8	6.30	153
2	Math	8	5	77.4	7.44	153
1	Reading	12	6	72.7	2.34	77
2	Reading	12	7	63.1	6.07	77
1	Reading	8	6	59.3	1.37	62
2	Reading	8	7	55.6	3.46	62

Table A2. Average Number of NAEP Items Rated at Each Cognitive Complexity Level

Workshop	Subject	Grade	# Reviewers	Level 1 Mean	Level 1 SD	Level 2 Mean	Level 2 SD	Level 3 Mean	Level 3 SD	Total Item N
1	Math	12	5	107.2	1.10	74.4	.55	9.4	1.14	191
2	Math	12	5	106.0	1.22	75	1.22	10.0	0	191
1	Math	8	5	89.6	2.70	59.6	2.51	3.8	.45	153
2	Math	8	5	88.2	2.59	58	2.35	6.8	.45	153
1	Reading	12	6	13.5	2.74	49.3	2.73	14.2	.75	77
2	Reading	12	7	15.4	3.36	48.3	3.82	13.3	1.50	77
1	Reading	8	6	13.2	1.83	36.7	2.50	12.2	1.17	62
2	Reading	8	7	11.7	3.95	39.6	2.44	10.7	1.80	62

Table A3. Average Number of NAEP Items Rated Higher, Same, Lower CCL as Linked WorkKeys Target

Workshop	Subject	Grade	# Reviewers	Items Higher Mean	Items Higher SD	Items Same Mean	Items Same SD	Items Lower Mean	Items Lower SD	Total Item N
1	Math	12	5	9.0	2	29.0	4.64	31.2	.84	191
2	Math	12	5	19.4	3.91	33.6	7.20	7.6	1.82	191
1	Math	8	5	5.6	1.14	52	5.24	29.2	3.11	153
2	Math	8	5	22.6	1.67	43.8	7.79	11	1	153
1	Reading	12	5	12.3	4.03	43.2	2.40	17.2	3.06	77
2	Reading	12	7	12.6	7.39	48.1	5.08	2.4	1.90	77
1	Reading	8	6	10.2	3.66	41.2	5.95	8.0	4.47	62
2	Reading	8	7	14.6	7.66	40.7	7.48	.4	.53	62

Table A4. Average Number of WorkKeys Items Linked to a NAEP Framework

Workshop	Subject	# Reviewers	# Items Matched Mean	# Items Matched SD	Total Item N
1	Math	6	33.0	0	33
2	Math	6	33.0	0	33
1	Applied Technology	6	22.8	1.94	34
2	Applied Technology	6	17.3	8.73	34
1	Reading	6	33.0	0	33
2	Reading	6	33.0	0	33
1	Locating Information	6	38.0	0	38
2	Locating Information	6	37.5	.84	38

Table A5. Average Number of WorkKeys Items Rated at Each Cognitive Complexity Level

Workshop	Subject	# Reviewers	Level 1 Mean	Level 1 SD	Level 2 Mean	Level 2 SD	Level 3 Mean	Level 3 SD	Total Item N
1	Math	6	18.5	4.72	14.3	4.84	.17	.41	33
2	Math	6	21.3	1.63	11.5	1.76	.17	.41	33
1	Applied Technology	6	19.0	4.38	15.0	4.38	0	0	34
2	Applied Technology	6	20.8	8.13	11.3	6.50	1.8	3.60	34
1	Reading	6	26.3	2.94	6.7	2.94	0	0	33
2	Reading	6	25.5	2.74	7.0	2.10	.5	.83	33
1	Locating Information	6	26.3	5.72	11.7	5.72	0	0	38
2	Locating Information	6	19.0	4.69	17.7	4.84	1.3	.82	38

Table A6. Average Number of WorkKeys Items Rated Higher, Same, Lower CCL as Linked NAEP Framework

Workshop	Subject	# Reviewers	Items Higher Mean	Items Higher SD	Items Same Mean	Items Same SD	Items Lower Mean	Items Lower SD	Total Item N
1	Math	6	2.3	.82	8.8	2.86	21.8	2.93	33
2	Math	6	6.3	1.97	24.0	2.83	2.8	1.33	33
1	Applied Technology	6	1.0	.89	4.8	1.72	17.0	1.41	34
2	Applied Technology	6	2.2	2.56	5.7	5.35	9.5	6.47	34
1	Reading	6	.33	.52	32.7	.52	0	0	33
2	Reading	6	.17	.41	32.7	.82	.17	.41	33
1	Locating Information	6	6.5	4.32	31.5	4.32	0	0	38
2	Locating Information	6	.33	.82	37.17	1.60	0	0	38

Table A7. Comparison of NAEP Math Frameworks and WorkKeys Math and Applied Technology Targets

NAEP Framework ID	Workshop 1 Rating	Workshop 2-A Rating	Workshop 2-B Rating	Final Decision
NS.a	Unique	Unique	WKM.4.3	Unique
NS.b	Unique	Unique	Unique	Unique
NS.c	WKM.3.2	WKM.6.1	WKM.3.2	WKM.3.2
NS.d	WKM.3.2	Unique	WKM.3.2	WKM.3.2
NS.e	WKM.3.2	Unique	WKM.3.2	WKM.3.2
NS.f	WKM.3.2	Unique	Unique	Unique
NS.g	WKM.3.2	Unique	WKM.3.2	WKM.3.2
NS.h	Unique	Unique	Unique	Unique
NS.i	Unique	Unique	Unique	Unique
NS.j	Unique	Unique	Unique	Unique
NS.k	Unique	Unique	Unique	Unique
NS.l	Unique	Unique	Unique	Unique
E.a	Unique	Unique	Unique	Unique
E.b	Unique	Unique	Unique	Unique
E.c	Unique	Unique	Unique	Unique
E.d	Unique	Unique	Unique	Unique
E.e	Unique	Unique	Unique	Unique
NO.a	Unique	WKM.6.1	Unique	Unique
NO.b	Unique	Unique	Unique	Unique
NO.c	WKM.4.4	Unique	Unique	Unique
NO.d	WKM.3.1	Unique	Unique	Unique
NO.e	WKM.4.6	Unique	WKM.4.6	WKM.4.6
NO.f	WKM.5.5	Unique	Unique	Unique
NO.g	WKM.6.1	Unique	Unique	Unique
NO.h	WKM.6.1	Unique	WKT.5.4	Matching- Unspecific
NO.i	WKM.6.1	Unique	WKT.5.4	Matching- Unspecific
RPR.a	WKM.4.3	Unique	WKM.4.3	WKM.4.3
RPR.b	WKM.4.3	WKM.6.1	WKM.4.3	WKM.4.3
RPR.c	WKM.7.5	WKM.7.5	WKM.4.3	WKM.7.5
RPR.d	WKM.7.5	WKM.6.1	WKM.4.3	Matching- Unspecific
RPR.e	WKM.5.6	WKM.6.1	WKM.5.6	WKM.5.6
RPR.f	WKM.6.1	WKM.6.1	WKM.6.1	WKM.6.1
PNO.a	Unique	Unique	Unique	Unique
PNO.b	Unique	Unique	Unique	Unique
PNO.c	Unique	Unique	Unique	Unique
PNO.d	Unique	Unique	Unique	Unique
PNO.e	Unique	Unique	Unique	Unique
PNO.f	Unique	Unique	WKM.4.2	Unique
PNO.g	WKM.4.1	WKM.4.1	WKM.4.2	WKM.4.1

NAEP Framework ID	Workshop 1 Rating	Workshop 2-A Rating	Workshop 2-B Rating	Final Decision
PNO.h	WKM.4.1	WKM.4.1	WKM.4.2	WKM.4.1
MRUN.a	Unique	Unique	WKM.5.1	Unique
MRUN.b	Unique	Unique	WKM.5.1	Unique
MRUN.c	Unique	Unique	WKM.5.1	Unique
MRUN.d	Unique	Unique	Unique	Unique
MPA.a	WKM.7.4	Unique	WKM.7.6	Matching- Unspecific
MPA.b	WKM.4.3	Unique	Unique	Unique
MPA.c	Unique	Unique	WKM.6.8	Unique
MPA.d	WKM.7.4	Unique	WKM.5.2	Matching- Unspecific
MPA.e	Unique	Unique	WKM.7.4	Unique
MPA.f	Unique	Unique	Unique	Unique
MPA.g	WKM.5.2	WKM.5.2	WKM.5.2	WKM.5.2
MPA.h	WKM.5.2	WKM.5.2	WKM.5.2	WKM.5.2
MPA.i	WKM.6.6	Unique	WKM.6.6	WKM.6.6
MPA.j	WKM.7.3	Unique	Unique	Unique
MPA.k	WKM.4.3	WKM.6.3	WKM.6.3	WKM.6.3
MPA.l	WKM.4.3	WKM.6.3	WKM.4.3	WKM.4.3
SM.a	WKM.5.1	WKM.5.1	Unique	WKM.5.1
SM.b	WKM.5.1	Unique	WKM.7.4	Matching- Unspecific
SM.c	WKM.5.3	Unique	Unique	Unique
SM.d	WKM.6.4	WKM.5.3	WKM.6.4	WKM.6.4
SM.e	WKM.7.2	WKM.5.3	WKM.6.4	Matching- Unspecific
SM.f	WKM.7.2	Unique	WKM.6.4	Matching- Unspecific
SM.g	WKM.5.1	Unique	WKM.7.4	Matching- Unspecific
SM.h	Unique	Unique	Unique	Unique
SM.i	Unique	Unique	Unique	Unique
SM.j	WKM.7.5	Unique	WKM.7.5	WKM.7.5
MT.a	Unique	Unique	WKM.7.5	Unique
MT.b	Unique	Unique	Unique	Unique
MT.c	Unique	Unique	Unique	Unique
MT.d	Unique	Unique	Unique	Unique
MT.e	Unique	Unique	Unique	Unique
MT.f	Unique	Unique	Unique	Unique
MT.g	Unique	Unique	Unique	Unique
MT.h	Unique	Unique	Unique	Unique
DS.a	Unique	Unique	Unique	Unique
DS.b	Unique	Unique	Unique	Unique
DS.c	Unique	Unique	Unique	Unique
DS.d	Unique	Unique	Unique	Unique
DS.e	Unique	Unique	Unique	Unique
DS.f	Unique	Unique	Unique	Unique

NAEP Framework ID	Workshop 1 Rating	Workshop 2-A Rating	Workshop 2-B Rating	Final Decision
DS.g	Unique	Unique	Unique	Unique
DS.h	WKM.7.3	Unique	Unique	Unique
DS.i	Unique	Unique	Unique	Unique
DS.j	WKM.7.3	Unique	Unique	Unique
TSPP.a	Unique	Unique	Unique	Unique
TSPP.b	Unique	Unique	Unique	Unique
TSPP.c	Unique	Unique	Unique	Unique
TSPP.d	Unique	Unique	Unique	Unique
TSPP.e	Unique	Unique	WKM.7.4	Unique
TSPP.f	Unique	Unique	Unique	Unique
TSPP.g	Unique	Unique	WKM.6.6	Unique
TSPP.h	Unique	Unique	WKM.4.3	Unique
TSPP.i	Unique	Unique	WKM.4.3	Unique
TSPP.j	Unique	Unique	Unique	Unique
RGF.a	Unique	Unique	WKM.4.2	Unique
RGF.b	Unique	Unique	WKM.4.2	Unique
RGF.c	WKM.7.5	Unique	WKM.4.2	Matching- Unspecific
RGF.d	WKM.7.4	Unique	Unique	Unique
RGF.e	Unique	Unique	WKM.4.2	Unique
RGF.f	Unique	Unique	WKM.4.2	Unique
RGF.g	Unique	Unique	Unique	Unique
RGF.h	Unique	Unique	Unique	Unique
RGF.i	Unique	Unique	Unique	Unique
RGF.j	Unique	Unique	Unique	Unique
RGF.k	Unique	Unique	Unique	Unique
RGF.l	Unique	Unique	Unique	Unique
PDC.a	Unique	Unique	Unique	Unique
PDC.b	Unique	Unique	Unique	Unique
PDC.c	Unique	Unique	Unique	Unique
PDC.d	Unique	Unique	Unique	Unique
PDC.e	Unique	Unique	Unique	Unique
PDC.f	Unique	Unique	Unique	Unique
PDC.g	Unique	Unique	Unique	Unique
PDC.h	Unique	Unique	Unique	Unique
PDC.i	Unique	Unique	Unique	Unique
PDC.j	Unique	Unique	Unique	Unique
PDC.k	Unique	Unique	Unique	Unique
MRG.a	Unique	Unique	Unique	Unique
MRG.b	Unique	Unique	Unique	Unique
MRG.c	Unique	Unique	WKT.6.6	Unique
MRG.d	Unique	Unique	Unique	Unique

NAEP Framework ID	Workshop 1 Rating	Workshop 2-A Rating	Workshop 2-B Rating	Final Decision
MRG.e	Unique	Unique	Unique	Unique
MRG.f	Unique	Unique	Unique	Unique
DR.a	WKM.7.8	Unique	Unique	Unique
DR.b	WKM.7.8	WKM.7.8	Unique	WKM.7.8
DR.c	WKM.7.8	WKM.7.8	WKM.7.8	WKM.7.8
DR.d	WKM.7.8	Unique	Unique	Unique
DR.e	WKM.7.8	Unique	Unique	Unique
DR.f	WKM.7.8	Unique	WKM.7.8	WKM.7.8
DR.g	WKM.7.8	Unique	Unique	Unique
DR.h	WKM.7.8	Unique	WKM.7.8	WKM.7.8
DR.i	WKM.7.8	Unique	Unique	Unique
DR.j	Unique	Unique	Unique	Unique
CDS.a	WKM.7.8	WKM.7.8	WKM.7.8	WKM.7.8
CDS.b	WKM.7.8	Unique	WKM.7.8	WKM.7.8
CDS.c	WKM.7.8	Unique	WKM.7.8	WKM.7.8
CDS.d	WKM.7.8	Unique	WKM.7.8	WKM.7.8
CDS.e	WKM.7.8	Unique	WKM.7.8	WKM.7.8
CDS.f	WKM.7.8	Unique	WKM.7.8	WKM.7.8
CDS.g	WKM.7.8	Unique	Unique	Unique
CDS.h	WKM.7.8	Unique	WKM.7.8	WKM.7.8
CDS.i	WKM.7.8	Unique	Unique	Unique
CDS.j	WKM.7.8	Unique	Unique	Unique
CDS.k	WKM.7.8	Unique	Unique	Unique
CDS.l	WKM.7.8	Unique	Unique	Unique
ES.a	Unique	Unique	Unique	Unique
ES.b	Unique	Unique	Unique	Unique
ES.c	Unique	Unique	Unique	Unique
ES.d	Unique	Unique	Unique	Unique
ES.e	WKM.7.8	Unique	Unique	Unique
ES.f	Unique	Unique	Unique	Unique
ES.g	Unique	Unique	Unique	Unique
ES.h	Unique	Unique	Unique	Unique
P.a	Unique	Unique	Unique	Unique
P.b	Unique	Unique	Unique	Unique
P.c	Unique	Unique	Unique	Unique
P.d	Unique	Unique	Unique	Unique
P.e	Unique	Unique	Unique	Unique
P.f	Unique	Unique	Unique	Unique
P.g	Unique	Unique	Unique	Unique
P.h	Unique	Unique	Unique	Unique
P.i	Unique	Unique	Unique	Unique

NAEP Framework ID	Workshop 1 Rating	Workshop 2-A Rating	Workshop 2-B Rating	Final Decision
P.j	Unique	Unique	Unique	Unique
P.k	Unique	Unique	Unique	Unique
P.l	Unique	Unique	Unique	Unique
P.m	Unique	Unique	Unique	Unique
P.n	Unique	Unique	Unique	Unique
P.o	Unique	Unique	Unique	Unique
P.p	Unique	Unique	Unique	Unique
P.q	Unique	Unique	Unique	Unique
MRD.a	Unique	Unique	Unique	Unique
MRD.b	Unique	Unique	WKM.5.1	Unique
MRD.c	Unique	Unique	Unique	Unique
MRD.d	Unique	Unique	Unique	Unique
MRD.e	Unique	Unique	Unique	Unique
PRF.a	Unique	Unique	Unique	Unique
PRF.b	Unique	Unique	Unique	Unique
PRF.c	Unique	Unique	Unique	Unique
PRF.d	Unique	Unique	Unique	Unique
PRF.e	Unique	Unique	Unique	Unique
PRF.f	Unique	Unique	Unique	Unique
PRF.g	Unique	Unique	Unique	Unique
PRF.h	Unique	Unique	Unique	Unique
PRF.i	Unique	Unique	Unique	Unique
PRF.j	Unique	Unique	Unique	Unique
PRF.k	Unique	Unique	Unique	Unique
PRF.l	Unique	Unique	Unique	Unique
AR.a	Unique	Unique	Unique	Unique
AR.b	WKM.6.2	Unique	Unique	Unique
AR.c	Unique	Unique	Unique	Unique
AR.d	Unique	Unique	Unique	Unique
AR.e	Unique	Unique	Unique	Unique
AR.f	Unique	Unique	Unique	Unique
AR.g	WKM.7.1	Unique	Unique	Unique
AR.h	Unique	Unique	Unique	Unique
AR.i	Unique	Unique	Unique	Unique
AR.j	Unique	Unique	Unique	Unique
AR.k	WKM.7.1	Unique	Unique	Unique
AR.l	Unique	Unique	Unique	Unique
VEO.a	Unique	Unique	Unique	Unique
VEO.b	Unique	Unique	Unique	Unique
VEO.c	Unique	Unique	Unique	Unique
VEO.d	Unique	Unique	Unique	Unique

NAEP Framework ID	Workshop 1 Rating	Workshop 2-A Rating	Workshop 2-B Rating	Final Decision
VEO.e	Unique	Unique	Unique	Unique
VEO.f	Unique	Unique	Unique	Unique
VEO.g	Unique	Unique	Unique	Unique
VEO.h	Unique	Unique	Unique	Unique
EI.a	Unique	Unique	Unique	Unique
EI.b	WKM.7.1	Unique	Unique	Unique
EI.c	Unique	Unique	Unique	Unique
EI.d	Unique	Unique	Unique	Unique
EI.e	WKM.7.1	Unique	Unique	Unique
EI.f	Unique	Unique	Unique	Unique
EI.g	Unique	Unique	Unique	Unique
EI.h	WKM.6.5	WKM.7.1	WKM.6.2	Matching- Unspecific
EI.i	Unique	Unique	Unique	Unique
EI.j	WKM.6.2	WKM.6.2	Unique	WKM.6.2
EI.k	Unique	Unique	Unique	Unique
MRA.a	Unique	Unique	Unique	Unique
MRA.b	Unique	Unique	Unique	Unique
MRA.c	Unique	Unique	Unique	Unique
MRA.d	Unique	Unique	Unique	Unique

Table A8. Comparison of Informational Component of the NAEP Reading Framework and WorkKeys Reading and Locating Information Targets

NAEP Framework ID	Workshop 1 Rating	Workshop 2-A Rating	Workshop 2-B Rating	Final Decision
LR.1	WKR.7.1 WKR.6.3 WKR.6.2 WKR.5.3 WKR.5.2 WKR.5.1 WKR.4.2 WKR.3.3 WKR.3.2 WKR 7.2	WKR.5.2 WKR.4.2 WKR.6.3 WKR.3.2 WKR.3.3 WKR.7.1 WKR.7.2 WKR.5.1 WKR.5.3	WKR.5.1 WKR.5.2 WKR.5.3 WKR.4.2 WKR.7.2 WKR.7.1 WKR.6.3 WKR.3.2 WKR.3.3	WKR.3.2, WKR.3.3, WKR.4.2, WKR.5.1, WKR.5.2, WKR.5.3, WKR.6.3, WKR.7.1, WKR.7.2
LR.2	Unique	Unique	Unique	Unique
LR.3	WKR.4.1 WKR.6.1 WKR.3.1	WKR.4.1	WKR.4.1	WKR.4.1
LR.4	WKR.3.1	WKR.3.1	WKR.6.5 WKR.3.1	WKR.3.1
LR.5	WKR.6.5	WKR.6.5	Unique	WKR.6.5
LR.6	WKR.4.5	WKR.4.5 WKL.5.3	WKR.4.5	WKR.4.5
LR.7	WKL.3.1 WKL.4.1 WKL.4.4	WKL.3.1 WKL.4.1 WKR.3.4	WKL.4.4 WKL.3.1 WKL.4.1	WKL.3.1, WKL.4.1, WKL.4.4
II.1	WKR.5.6	WKL.6.3	Unique	Matching-Unspecific
II.2	WKL.4.5 WKL.5.4 WKL.4.2	WKL.5.4 WKL.4.5 WKR.4.3 WKR.3.5 WKL.4.2 WKL.3.2	Unique	WKL.4.2, WKL.4.5, WKL.5.4
II.3	Unique	WKL.6.2 WKR.6.1	WKR.6.1	WKR.6.1
II.4	Unique	Unique	Unique	Unique
II.5	WKL.4.3 WKL.5.2	WKL.4.3 WKR.6.6 WKL.4.4 WKL.5.2	Unique	WKL.4.3, WKL.5.2
II.6	WKL.5.3 WKL.6.2 WKL.6.3	WKL.6.1 WKR.4.4	Unique	Matching
II.7	Unique	Unique	Unique	Unique
II.8	Unique	Unique	Unique	Unique
II.9	WKR.6.7	WKL.5.1	Unique	Matching-Unspecific
CE.1	Unique	Unique	Unique	Unique
CE.2	WKR.6.5	Unique	Unique	Unique
CE.3	Unique	Unique	Unique	Unique

NAEP Framework ID	Workshop 1 Rating	Workshop 2-A Rating	Workshop 2-B Rating	Final Decision
CE.4	WKL.6.1	Unique	Unique	Unique
CE.5	Unique	Unique	Unique	Unique
CE.6	Unique	Unique	Unique	Unique
CE.7	Unique	Unique	Unique	Unique
CE.8	Unique	Unique	Unique	Unique

Appendix B: NAEP Frameworks and WorkKeys Targets

Table B1. NAEP Math Frameworks

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Number properties and operations	Number Sense	8	NS.a	a) Use place value to model and describe integers and decimals.
Number properties and operations	Number Sense	8	NS.b	b) Model or describe rational numbers or numerical relationships using number lines and diagrams.
Number properties and operations	Number Sense	8	NS.c	c) Write or rename rational numbers.
Number properties and operations	Number Sense	8	NS.d	d) Recognize, translate or apply multiple representations of rational numbers (fractions, decimals, and percents) in meaningful contexts.
Number properties and operations	Number Sense	8	NS.e	e) Express or interpret numbers using scientific notation from real-life contexts.
Number properties and operations	Number sense	12	NS.f	f) Represent, interpret, or compare expressions for real numbers, including expressions using exponents and logarithms.
Number properties and operations	Number sense	12	NS.g	g) Represent or interpret expressions involving very large or very small numbers in scientific notation.
Number properties and operations	Number Sense	8	NS.h	h) Find or model absolute value or apply to problem situations.
Number properties and operations	Number sense	12	NS.i	i) Represent, interpret, or compare expressions or problem situations involving absolute values.
Number properties and operations	Number Sense	8	NS.j	j) Order or compare rational numbers (fractions, decimals, percents, or integers) using various models and representations (e.g., number line).
Number properties and operations	Number sense	12	NS.k	k) Order or compare real numbers, including very large and very small real numbers.
Number properties and operations	Number Sense	8	NS.l	l) Order or compare rational numbers including very large and small integers, and decimals and fractions close to zero.
Number properties and operations	Estimation	8	E.a	a) Establish or apply benchmarks for rational numbers and common irrational numbers (e.g., π) in contexts.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Number properties and operations	Estimation	8	E.b	b) Make estimates appropriate to a given situation by: Identifying when estimation is appropriate, determining the level of accuracy needed, selecting the appropriate method of estimation, or analyzing the effect of an estimation method on the accuracy of results.
Number properties and operations	Estimation	12	E.c	c) Identify situations where estimation is appropriate, determine the needed degree of accuracy, and analyze the effect of the estimation method on the accuracy of results.
Number properties and operations	Estimation	8,12	E.d	d) Verify solutions or determine the reasonableness of results in a variety of situations, including calculator and computer results.
Number properties and operations	Estimation	8,12	E.e	e) Estimate square or cube roots of numbers less than 1,000 between two whole numbers.
Number properties and operations	Number operations	8	NO.a	a) Perform computations with rational numbers.
Number properties and operations	Number operations	12	NO.b	b) Find integral or simple fractional powers of real numbers.
Number properties and operations	Number operations	12	NO.c	c) Perform arithmetic operations with real numbers, including common irrational numbers.
Number properties and operations	Number operations	12	NO.d	d) Perform arithmetic operations with expressions involving absolute value.
Number properties and operations	Number operations	8	NO.e	e) Describe the effect of multiplying and dividing by numbers including the effect of multiplying or dividing a rational number by: zero, or a number less than zero, or a number between zero and one, one, or a number greater than one.
Number properties and operations	Number operations	12	NO.f	f) Describe the effect of multiplying and dividing by numbers including the effect of multiplying or dividing a real number by: Zero, or a number less than zero, or a number between zero and one, or one, or a number greater than one.
Number properties and operations	Number operations	8	NO.g	g) Interpret rational number operations (add, subtract, multiply, and divide) and the relationships between them.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Number properties and operations	Number operations	8	NO.h	h) Solve application problems involving rational numbers and operations using exact answers or estimates as appropriate.
Number properties and operations	Number operations	12	NO.i	i) Solve application problems involving numbers, including rational and common irrationals.
Number properties and operations	Ratios and Proportional Reasoning	8	RPR.a	a) Use ratios to describe problem situations.
Number properties and operations	Ratios and Proportional Reasoning	8	RPR.b	b) Use fractions to represent and express ratios and proportions.
Number properties and operations	Ratios and Proportional Reasoning	8	RPR.c	c) Use proportional reasoning to model and solve problems (including rates and scaling).
Number properties and operations	Ratios and proportional reasoning	12	RPR.d	d) Use proportions to solve problems (including rates of change).
Number properties and operations	Ratios and Proportional Reasoning	8	RPR.e	e) Solve problems involving percentages (including percent increase and decrease, interest rates, tax, discount, tips, or part/whole relationships).
Number properties and operations	Ratios and proportional reasoning	12	RPR.f	f) Solve multistep problems involving percentages, including compound percentages.
Number properties and operations	Properties of number and operations	8	PNO.a	a) Describe odd and even integers and how they behave under different operations.
Number properties and operations	Properties of number and operations	8	PNO.b	b) Recognize, find, or use factors, multiples, or prime factorization.
Number properties and operations	Properties of numbers and operations	12	PNO.c	c) Solve problems using factors, multiples, or prime factorization.
Number properties and operations	Properties of number and operations	8	PNO.d	d) Recognize or use prime and composite numbers to solve problems.
Number properties and operations	Properties of numbers and operations	12	PNO.e	e) Recognize properties of the number system (whole numbers, integers, rational numbers, real numbers, and complex numbers) and how they are related to each other, and identify examples of each type of number.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Number properties and operations	Properties of number and operations	8,12	PNO.f	f) Use divisibility or remainders in problem settings.
Number properties and operations	Properties of number and operations	8	PNO.g	g) Apply basic properties of operations.
Number properties and operations	Properties of numbers and operations	12	PNO.h	h) Apply basic properties of operations, including conventions about the order of operations.
Number properties and operations	Mathematical reasoning and using numbers	8	MRUN.a	a) Explain or justify a mathematical concept or relationship (e.g., explain why 17 is prime).
Number properties and operations	Mathematical reasoning and using numbers	8	MRUN.b	b) Provide a mathematical argument to explain operations with two or more fractions.
Number properties and operations	Mathematical reasoning using numbers	12	MRUN.c	c) Give a mathematical argument to establish the validity of a simple numerical property or relationship.
Number properties and operations	Mathematical reasoning using numbers	12	MRUN.d	d) Analyze or interpret a proof by mathematical induction of a simple numerical relationship.
Measurement	Measuring physical attributes	8	MPA.a	a) Compare objects with respect to length, area, volume, angle measurement, weight, or mass.
Measurement	Measuring physical attributes	12	MPA.b	b) Determine the effect of proportions and scaling on length, area, and volume.
Measurement	Measuring physical attributes	8	MPA.c	c) Estimate the size of an object with respect to a given measurement attribute (e.g., area).
Measurement	Measuring physical attributes	12	MPA.d	d) Estimate or compare perimeters or areas of two-dimensional geometric figures.
Measurement	Measuring physical attributes	8	MPA.e	e) Select or use appropriate measurement instrument to determine or create a given length, area, volume, angle, weight, or mass.
Measurement	Measuring physical attributes	12	MPA.f	f) Solve problems of angle measure, including those involving triangles or other polygons or parallel lines cut by a transversal.
Measurement	Measuring physical attributes	8	MPA.g	g) Solve mathematical or real-world problems involving perimeter or area of plane figures such as triangles, rectangles, circles, or composite figures.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Measurement	Measuring physical attributes	12	MPA.h	h) Solve problems involving perimeter or area of plane figures such as polygons, circles, or composite figures.
Measurement	Measuring physical attributes	8	MPA.i	i) Solve problems involving volume or surface area of rectangular solids, cylinders, prisms, or composite shapes.
Measurement	Measuring physical attributes	12	MPA.j	j) Solve problems by determining, estimating, or comparing volumes or surface areas of three-dimensional figures.
Measurement	Measuring physical attributes	8	MPA.k	k) Solve problems involving rates such as speed or population density.
Measurement	Measuring physical attributes	12	MPA.l	l) Solve problems involving rates such as speed, density, population density, or flow rates.
Measurement	Systems of measurement	8	SM.a	a) Select or use an appropriate type of unit for the attribute being measured such as length, area, angle, time, or volume.
Measurement	Systems of measurement	12	SM.b	b) Recognize that geometric measurements (length, area, perimeter, and volume) depend on the choice of a unit, and apply such units in expressions, equations, and problem solutions.
Measurement	Systems of measurement	12	SM.c	c) Understand that numerical values associated with measurements of physical quantities are approximate, are subject to variation, and must be assigned units of measurement.
Measurement	Systems of measurement	8	SM.d	d) Solve problems involving conversions within the same measurement system such as conversions involving square inches and square feet.
Measurement	Systems of measurement	12	SM.e	e) Solve problems involving conversions within or between measurement systems, given the relationship between the units.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Measurement	Systems of measurement	8	SM.f	f) Estimate the measure of an object in one system given the measure of that object in another system and the approximate conversion factor. For example: Distance conversion: 1 kilometer is approximately 5/8 of a mile. Money conversion: U.S. dollars to Canadian dollars. Temperature conversion: Fahrenheit to Celsius.
Measurement	Systems of measurement	8	SM.g	g) Determine appropriate size of unit of measurement in problem situation involving such attributes as length, area, or volume.
Measurement	Systems of measurement	8	SM.h	h) Determine appropriate accuracy of measurement in problem situations (e.g., the accuracy of each of several lengths needed to obtain a specified accuracy of a total length) and find the measure to that degree of accuracy.
Measurement	Systems of measurement	12	SM.i	i) Determine appropriate accuracy of measurement in problem situations (e.g., the accuracy of measurement of the dimensions to obtain a specified accuracy of area) and find the measure to that degree of accuracy.
Measurement	Systems of measurement	12	SM.j	j) Construct or solve problems involving scale drawings.
Measurement	Measurement in triangles	8	MT.a	a) Solve problems involving indirect measurement such as finding the height of a building by comparing its shadow with the height and shadow of a known object.
Measurement	Measurement in triangles	12	MT.b	b) Solve problems involving indirect measurement.
Measurement	Measurement in triangles	12	MT.c	c) Solve problems using the fact that trigonometric ratios (sine, cosine, and tangent) stay constant in similar triangles.
Measurement	Measurement in triangles	12	MT.d	d) Use the definitions of sine, cosine, and tangent as ratios of sides in a right triangle to solve problems about length of sides and measure of angles.
Measurement	Measurement in triangles	12	MT.e	e) Interpret and use the identity $\sin^2 q + \cos^2 q = 1$ for angles q between 0° and 90°; recognize this identity as a special representation of the Pythagorean theorem.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Measurement	Measurement in triangles	12	MT.f	f) Determine the radian measure of an angle and explain how radian measurement is related to a circle of radius 1.
Measurement	Measurement in triangles	12	MT.g	g) Use trigonometric formulas such as addition and double angle formulas.
Measurement	Measurement in triangles	12	MT.h	h) Use the law of cosines and the law of sines to find unknown sides and angles of a triangle.
Geometry	Dimension and shape	8	DS.a	a) Draw or describe a path of shortest length between points to solve problems in context.
Geometry	Dimension and shape	8	DS.b	b) Identify a geometric object given a written description of its properties.
Geometry	Dimension and shape	8	DS.c	c) Identify, define, or describe geometric shapes in the plane and in three-dimensional space given a visual representation.
Geometry	Dimension and shape	12	DS.d	d) Give precise mathematical descriptions or definitions of geometric shapes in the plane and in three-dimensional space.
Geometry	Dimension and shape	8	DS.e	e) Draw or sketch from a written description polygons, circles, or semicircles.
Geometry	Dimension and shape	12	DS.f	f) Draw or sketch from a written description plane figures and planar images of three-dimensional figures.
Geometry	Dimension and shape	8	DS.g	g) Represent or describe a three-dimensional situation in a two-dimensional drawing from different views.
Geometry	Dimension and shape	12	DS.h	h) Use two-dimensional representations of three-dimensional objects to visualize and solve problems.
Geometry	Dimension and shape	8	DS.i	i) Demonstrate an under-standing about the two- and three-dimensional shapes in our world through identifying, drawing, modeling, building, or taking apart.
Geometry	Dimension and shape	12	DS.j	j) Analyze properties of three-dimensional figures including spheres and hemispheres.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Geometry	Transformation of shapes and preservation of properties	8	TSPP.a	a) Identify lines of symmetry in plane figures or recognize and classify types of symmetries of plane figures.
Geometry	Transformation of shapes and preservation of properties	12	TSPP.b	b) Recognize or identify types of symmetries (e.g., point, line, rotational, self-congruence) of two- and three-dimensional figures.
Geometry	Transformation of shapes and preservation of properties	8	TSPP.c	c) Recognize or informally describe the effect of a transformation on two-dimensional geometric shapes (reflections across lines of symmetry, rotations, translations, magnifications, and contractions).
Geometry	Transformation of shapes and preservation of properties	12	TSPP.d	d) Give or recognize the precise mathematical relationship (e.g., congruence, similarity, orientation) between a figure and its image under a transformation.
Geometry	Transformation of shapes and preservation of properties	8	TSPP.e	e) Predict results of combining, subdividing, and changing shapes of plane figures and solids (e.g., paper folding, tiling, cutting up and rearranging pieces).
Geometry	Transformation of shapes and preservation of properties	12	TSPP.f	f) Perform or describe the effect of a single transformation on two- and three-dimensional geometric shapes (reflections across lines of symmetry, rotations, translations, and dilations).
Geometry	Transformation of shapes and preservation of properties	12	TSPP.g	g) Identify transformations, combinations, or subdivisions of shapes that preserve the area of two-dimensional figures or the volume of three-dimensional figures.
Geometry	Transformation of shapes and preservation of properties	8,12	TSPP.h	h) Justify relationships of congruence and similarity and apply these relationships using scaling and proportional reasoning.
Geometry	Transformation of shapes and preservation of properties	8	TSPP.i	i) For similar figures, identify and use the relationships of conservation of angle and of proportionality of side length and perimeter.
Geometry	Transformation of shapes and preservation of properties	12	TSPP.j	j) Perform or describe the effects of successive transformations.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Geometry	Relationships between geometric figures	8	RGF.a	a) Apply geometric properties and relationships in solving simple problems in two and three dimensions.
Geometry	Relationships between geometric figures	12	RGF.b	b) Apply geometric properties and relationships to solve problems in two and three dimensions.
Geometry	Relationships between geometric figures	8	RGF.c	c) Represent problem situations with simple geometric models to solve mathematical or real-world problems.
Geometry	Relationships between geometric figures	12	RGF.d	d) Represent problem situations with geometric models to solve mathematical or real-world problems.
Geometry	Relationships between geometric figures	8	RGF.e	e) Use the Pythagorean theorem to solve problems.
Geometry	Relationships between geometric figures	12	RGF.f	f) Use the Pythagorean theorem to solve problems in two- or three-dimensional situations.
Geometry	Relationships between geometric figures	8	RGF.g	g) Describe or analyze simple properties of, or relationships between, triangles, quadrilaterals, and other polygonal plane figures.
Geometry	Relationships between geometric figures	12	RGF.h	h) Recall and interpret definitions and basic properties of congruent and similar triangles, circles, quadrilaterals, polygons, parallel, perpendicular and intersecting lines, and associated angle relationships.
Geometry	Relationships between geometric figures	12	RGF.i	i) Analyze properties or relationships of triangles, quadrilaterals, and other polygonal plane figures.
Geometry	Relationships between geometric figures	8	RGF.j	j) Describe or analyze properties and relationships of parallel or intersecting lines.
Geometry	Relationships between geometric figures	12	RGF.k	k) Analyze properties and relationships of parallel, perpendicular, or intersecting lines including the angle relationships that arise in these cases.
Geometry	Relationships between geometric figures	12	RGF.l	l) Analyze properties of circles and the intersections of lines and circles (inscribed angles, central angles, tangents, secants, and chords).

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Geometry	Position, direction, and coordinate geometry	8	PDC.a	a) Describe relative positions of points and lines using the geometric ideas of midpoint, points on common line through a common point, parallelism, or perpendicularity.
Geometry	Position, direction, and coordinate geometry	8	PDC.b	b) Describe the intersection of two or more geometric figures in the plane (e.g., intersection of a circle and a line).
Geometry	Position, direction, and coordinate geometry	12	PDC.c	c) Describe the intersections of lines in the plane and in space, intersections of a line and a plane, or of two planes in space.
Geometry	Position, direction, and coordinate geometry	8	PDC.d	d) Visualize or describe the cross section of a solid.
Geometry	Position, direction, and coordinate geometry	12	PDC.e	e) Describe or identify conic sections and other cross sections of solids.
Geometry	Position, direction, and coordinate geometry	8	PDC.f	f) Represent geometric figures using rectangular coordinates on a plane.
Geometry	Position, direction, and coordinate geometry	12	PDC.g	g) Represent two-dimensional figures algebraically using coordinates and/or equations.
Geometry	Position, direction, and coordinate geometry	12	PDC.h	h) Use vectors to represent velocity and direction; multiply a vector by a scalar and add vectors both algebraically and graphically.
Geometry	Position, direction, and coordinate geometry	12	PDC.i	i) Find an equation of a circle given its center and radius and, given an equation of a circle, find its center and radius.
Geometry	Position, direction, and coordinate geometry	12	PDC.j	j) Graph ellipses and hyperbolas whose axes are parallel to the coordinate axes and demonstrate understanding of the relationship between their standard algebraic form and their graphical characteristics.
Geometry	Position, direction, and coordinate geometry	12	PDC.k	k) Represent situations and solve problems involving polar coordinates.
Geometry	Mathematical reasoning in geometry	8	MRG.a	a) Make and test a geometric conjecture about regular polygons.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Geometry	Mathematical reasoning in geometry	12	MRG.b	b) Make, test, and validate geometric conjectures using a variety of methods including deductive reasoning and counterexamples.
Geometry	Mathematical reasoning in geometry	12	MRG.c	c) Determine the role of hypotheses, logical implications, and conclusion in proofs of geometric theorems.
Geometry	Mathematical reasoning in geometry	12	MRG.d	d) Analyze or explain a geometric argument by contradiction.
Geometry	Mathematical reasoning in geometry	12	MRG.e	e) Analyze or explain a geometric proof of the Pythagorean theorem.
Geometry	Mathematical reasoning in geometry	12	MRG.f	f) Prove basic theorems about congruent and similar triangles and circles.
Data analysis, statistics, and probability	Data representation	8	DR.a	a) Read or interpret data, including interpolating or extrapolating from data.
Data analysis, statistics, and probability	Data representation	12	DR.b	b) Read or interpret graphical or tabular representations of data.
Data analysis, statistics, and probability	Data representation	8,12	DR.c	c) For a given set of data, complete a graph and then solve a problem using the data in the graph (histograms, line graphs, scatterplots, circle graphs, and bar graphs).
Data analysis, statistics, and probability	Data representation	8	DR.d	d) Solve problems by estimating and computing with data from a single set or across sets of data.
Data analysis, statistics, and probability	Data representation	12	DR.e	e) Solve problems involving univariate or bivariate data.
Data analysis, statistics, and probability	Data representation	8	DR.f	f) Given a graph or a set of data, determine whether information is represented effectively and appropriately (histograms, line graphs, scatterplots, circle graphs, and bar graphs).
Data analysis, statistics, and probability	Data representation	12	DR.g	g) Given a graphical or tabular representation of a set of data, determine whether information is represented effectively and appropriately.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Data analysis, statistics, and probability	Data representation	8	DR.h	h) Compare and contrast the effectiveness of different representations of the same data.
Data analysis, statistics, and probability	Data representation	12	DR.i	i) Compare and contrast different graphical representations of univariate and bivariate data.
Data analysis, statistics, and probability	Data representation	12	DR.j	j) Organize and display data in a spreadsheet in order to recognize patterns and solve problems.
Data analysis, statistics, and probability	Characteristics of data sets	8	CDS.a	a) Calculate, use, or interpret mean, median, mode, or range.
Data analysis, statistics, and probability	Characteristics of data sets	8	CDS.b	b) Describe how mean, median, mode, range, or interquartile ranges relate to distribution shape.
Data analysis, statistics, and probability	Characteristics of data	12	CDS.c	c) Calculate, interpret, or use summary statistics for distributions of data including measures of typical value (mean, median), position (quartiles, percentiles), and spread (range, interquartile range, variance, and standard deviation).
Data analysis, statistics, and probability	Characteristics of data	12	CDS.d	d) Recognize how linear transformations of one-variable data affect mean, median, mode, range, interquartile range, and standard deviation.
Data analysis, statistics, and probability	Characteristics of data sets	8	CDS.e	e) Identify outliers and determine their effect on mean, median, mode, or range.
Data analysis, statistics, and probability	Characteristics of data	12	CDS.f	f) Determine the effect of outliers on mean, median, mode, range, interquartile range, or standard deviation.
Data analysis, statistics, and probability	Characteristics of data sets	8	CDS.g	g) Using appropriate statistical measures, compare two or more data sets describing the same characteristic for two different populations or subsets of the same population.
Data analysis, statistics, and probability	Characteristics of data	12	CDS.h	h) Compare data sets using summary statistics (mean, median, mode, range, interquartile range, or standard deviation) describing the same characteristic for two different populations or subsets of the same population.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Data analysis, statistics, and probability	Characteristics of data sets	8	CDS.i	i) Visually choose the line that best fits given a scatterplot and informally explain the meaning of the line. Use the line to make predictions.
Data analysis, statistics, and probability	Characteristics of data	12	CDS.j	j) Approximate a trend line if a linear pattern is apparent in a scatterplot or use a graphing calculator to determine a least-squares regression line and use the line or equation to make predictions.
Data analysis, statistics, and probability	Characteristics of data	12	CDS.k	k) Recognize that the correlation coefficient is a number from –1 to +1 that measures the strength of the linear relationship between two variables; visually estimate the correlation coefficient (e.g., positive or negative, closer to 0, .5, or 1.0) of a scatterplot.
Data analysis, statistics, and probability	Characteristics of data	12	CDS.l	l) Know and interpret the key characteristics of a normal distribution such as shape, center (mean), and spread (standard deviation).
Data analysis, statistics, and probability	Experiments and samples	8	ES.a	a) Given a sample, identify possible sources of bias in sampling.
Data analysis, statistics, and probability	Experiments and samples	12	ES.b	b) Identify possible sources of bias in sample surveys and describe how such bias can be controlled and reduced.
Data analysis, statistics, and probability	Experiments and samples	8	ES.c	c) Distinguish between a random and nonrandom sample.
Data analysis, statistics, and probability	Experiments and samples	12	ES.d	d) Recognize and describe a method to select a simple random sample.
Data analysis, statistics, and probability	Experiments and samples	12	ES.e	e) Draw inferences from samples, such as estimates of proportions in a population, estimates of population means, or decisions about differences in means for two “treatments.”
Data analysis, statistics, and probability	Experiments and samples	8	ES.f	f) Evaluate the design of an experiment.
Data analysis, statistics, and probability	Experiments and samples	12	ES.g	g) Identify or evaluate the characteristics of a good survey or of a well-designed experiment.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Data analysis, statistics, and probability	Experiments and samples	12	ES.h	h) Recognize the differences in design and in conclusions between randomized experiments and observational studies.
Data analysis, statistics, and probability	Probability	8	P.a	a) Analyze a situation that involves probability of an independent event.
Data analysis, statistics, and probability	Probability	12	P.b	b) Recognize whether two events are independent or dependent.
Data analysis, statistics, and probability	Probability	8	P.c	c) Determine the theoretical probability of simple and compound events in familiar contexts.
Data analysis, statistics, and probability	Probability	12	P.d	d) Determine the theoretical probability of simple and compound events in familiar or unfamiliar contexts.
Data analysis, statistics, and probability	Probability	8	P.e	e) Estimate the probability of simple and compound events through experimentation or simulation.
Data analysis, statistics, and probability	Probability	12	P.f	f) Given the results of an experiment or simulation, estimate the probability of simple or compound events in familiar or unfamiliar contexts.
Data analysis, statistics, and probability	Probability	8,12	P.g	g) Use theoretical probability to evaluate or predict experimental outcomes.
Data analysis, statistics, and probability	Probability	8	P.h	h) Determine the sample space for a given situation.
Data analysis, statistics, and probability	Probability	8	P.i	i) Use a sample space to determine the probability of possible outcomes for an event.
Data analysis, statistics, and probability	Probability	12	P.j	j) Determine the number of ways an event can occur using tree diagrams, formulas for combinations and permutations, or other counting techniques.
Data analysis, statistics, and probability	Probability	8	P.k	k) Represent the probability of a given outcome using fractions, decimals, and percents.
Data analysis, statistics, and probability	Probability	8	P.l	l) Determine the probability of independent and dependent events. (Dependent events should be limited to a small sample size.)

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Data analysis, statistics, and probability	Probability	12	P.m	m) Determine the probability of independent and dependent events.
Data analysis, statistics, and probability	Probability	12	P.n	n) Determine conditional probability using two-way tables.
Data analysis, statistics, and probability	Probability	8	P.o	o) Interpret probabilities within a given context.
Data analysis, statistics, and probability	Probability	12	P.p	p) Interpret and apply probability concepts to practical situations.
Data analysis, statistics, and probability	Probability	12	P.q	q) Use the binomial theorem to solve problems.
Data analysis, statistics, and probability	Mathematical reasoning with data	12	MRD.a	a) Identify misleading uses of data in real-world settings and critique different ways of presenting and using information.
Data analysis, statistics, and probability	Mathematical reasoning with data	12	MRD.b	b) Distinguish relevant from irrelevant information, identify missing information, and either find what is needed or make appropriate approximations.
Data analysis, statistics, and probability	Mathematical reasoning with data	12	MRD.c	c) Recognize, use, and distinguish between the processes of mathematical (deterministic) and statistical modeling.
Data analysis, statistics, and probability	Mathematical reasoning with data	12	MRD.d	d) Recognize when arguments based on data confuse correlation with causation.
Data analysis, statistics, and probability	Mathematical reasoning with data	12	MRD.e	e) Recognize and explain the potential errors caused by extrapolating from data.
Algebra	Patterns, relations, and functions	8	PRF.a	a) Recognize, describe, or extend numerical and geometric patterns using tables, graphs, words, or symbols.
Algebra	Patterns, relations, and functions	12	PRF.b	b) Recognize, describe, or extend numerical patterns, including arithmetic and geometric progressions.
Algebra	Patterns, relations, and functions	8	PRF.c	c) Generalize a pattern appearing in a numerical sequence, table, or graph using words or symbols.
Algebra	Patterns, relations, and functions	12	PRF.d	d) Determine whether a relation, given in verbal, symbolic, tabular, or graphical form, is a function.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Algebra	Patterns, relations, and functions	8	PRF.e	e) Analyze or create patterns, sequences, or linear functions given a rule.
Algebra	Patterns, relations, and functions	12	PRF.f	f) Express linear and exponential functions in recursive and explicit form given a table, verbal description, or some terms of a sequence.
Algebra	Patterns, relations, and functions	8	PRF.g	g) Identify functions as linear or nonlinear or contrast distinguishing properties of functions from tables, graphs, or equations.
Algebra	Patterns, relations, and functions	12	PRF.h	h) Identify or analyze distinguishing properties of linear, quadratic, rational, exponential, or trigonometric functions from tables, graphs, or equations.
Algebra	Patterns, relations, and functions	8	PRF.i	i) Interpret the meaning of slope or intercepts in linear functions.
Algebra	Patterns, relations, and functions	12	PRF.j	j) Recognize and analyze the general forms of linear, quadratic, rational, exponential, or trigonometric functions.
Algebra	Patterns, relations, and functions	12	PRF.k	k) Determine the domain and range of functions given in various forms and contexts.
Algebra	Patterns, relations, and functions	12	PRF.l	l) Given a function, determine its inverse if it exists and explain the contextual meaning of the inverse for a given situation.
Algebra	Algebraic representations	8	AR.a	a) Translate between different representations of linear expressions using symbols, graphs, tables, diagrams, or written descriptions.
Algebra	Algebraic representations	12	AR.b	b) Create and translate between different representations of algebraic expressions, equations, and inequalities (e.g., linear, quadratic, exponential, or trigonometric) using symbols, graphs, tables, diagrams, or written descriptions.
Algebra	Algebraic representations	8	AR.c	c) Analyze or interpret linear relationships expressed in symbols, graphs, tables, diagrams, or written descriptions.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Algebra	Algebraic representations	12	AR.d	d) Analyze or interpret relationships expressed in symbols, graphs, tables, diagrams (including Venn diagrams), or written descriptions and evaluate the relative advantages or disadvantages of different representations to answer specific questions.
Algebra	Algebraic representations	8	AR.e	e) Graph or interpret points represented by ordered pairs of numbers on a rectangular coordinate system.
Algebra	Algebraic representations	8	AR.f	f) Solve problems involving coordinate pairs on the rectangular coordinate system.
Algebra	Algebraic representations	8	AR.g	g) Identify or represent functional relationships in meaningful contexts including proportional, linear, and common nonlinear (e.g., compound interest, bacterial growth) in tables, graphs, words, or symbols.
Algebra	Algebraic representations	12	AR.h	h) Perform or interpret transformations on the graphs of linear, quadratic, exponential, and trigonometric functions.
Algebra	Algebraic representations	12	AR.i	i) Make inferences or predictions using an algebraic model of a situation.
Algebra	Algebraic representations	12	AR.j	j) Given a real-world situation, determine if a linear, quadratic, rational, exponential, logarithmic, or trigonometric function fits the situation.
Algebra	Algebraic representations	12	AR.k	k) Solve problems involving exponential growth and decay.
Algebra	Algebraic representations	12	AR.l	l) Analyze properties of exponential, logarithmic, and rational functions.
Algebra	Variables, expressions, and operations	8,12	VEO.a	a) Write algebraic expressions, equations, or inequalities to represent a situation.
Algebra	Variables, expressions, and operations	8	VEO.b	b) Perform basic operations, using appropriate tools, on linear algebraic expressions (including grouping and order of multiple operations involving basic operations, exponents, roots, simplifying, and expanding).

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Algebra	Variables, expressions, and operations	12	VEO.c	c) Perform basic operations, using appropriate tools, on algebraic expressions including polynomial and rational expressions.
Algebra	Variables, expressions, and operations	12	VEO.d	d) Write equivalent forms of algebraic expressions, equations, or inequalities to represent and explain mathematical relationships.
Algebra	Variables, expressions, and operations	12	VEO.e	e) Evaluate algebraic expressions including polynomials and rational expressions.
Algebra	Variables, expressions, and operations	12	VEO.f	f) Use function notation to evaluate a function at a specified point in its domain and combine functions by addition, subtraction, multiplication, division, and composition.
Algebra	Variables, expressions, and operations	12	VEO.g	g) Determine the sum of finite and infinite arithmetic and geometric series.
Algebra	Variables, expressions, and operations	12	VEO.h	h) Use basic properties of exponents and logarithms to solve problems.
Algebra	Equations and inequalities	8	EI.a	a) Solve linear equations or inequalities (e.g., **a*x* + b = c** or **a*x* + b = c*x* + d** or **a*x* + b > c**).
Algebra	Equations and inequalities	12	EI.b	b) Solve linear, rational, or quadratic equations or inequalities, including those involving absolute value.
Algebra	Equations and inequalities	8	EI.c	c) Interpret "=" as an equivalence between two expressions and use this interpretation to solve problems.
Algebra	Equations and inequalities	8	EI.d	d) Analyze situations or solve problems using linear equations and inequalities with rational coefficients symbolically or graphically (e.g., **a*x* + b = c** or **a*x* + b = c*x* + d**).
Algebra	Equations and inequalities	12	EI.e	e) Analyze situations, develop mathematical models, or solve problems using linear, quadratic, exponential, or logarithmic equations or inequalities symbolically or graphically.
Algebra	Equations and inequalities	12	EI.f	f) Solve (symbolically or graphically) a system of equations or inequalities and recognize the relationship between the analytical solution and graphical solution.

Content Area	Subtopic	Grade	HumRRO ID	Objectives
Algebra	Equations and inequalities	8	EI.g	g) Interpret relationships between symbolic linear expressions and graphs of lines by identifying and computing slope and intercepts (e.g., know in $y = ax + b$, that **a** is the rate of change and **b** is the vertical intercept of the graph).
Algebra	Equations and inequalities	12	EI.h	h) Use and evaluate common formulas (e.g., relationship between a circle's circumference and diameter [**C = pi d**], distance and time under constant speed).
Algebra	Equations and inequalities	12	EI.i	i) Solve problems involving special formulas such as: $A = P(1 + r)^t$ or $A = Pe^{rt}$.
Algebra	Equations and inequalities	12	EI.j	j) Solve an equation or formula involving several variables for one variable in terms of the others.
Algebra	Equations and inequalities	8	EI.k	k) Solve quadratic equations with complex roots.
Algebra	Mathematical reasoning and algebra	8	MRA.a	a) Make, validate, and justify conclusions and generalizations about linear relationships.
Algebra	Mathematical reasoning in algebra	12	MRA.b	b) Use algebraic properties to develop a valid mathematical argument.
Algebra	Mathematical reasoning in algebra	12	MRA.c	c) Determine the role of hypotheses, logical implications, and conclusions in algebraic argument.
Algebra	Mathematical reasoning in algebra	12	MRA.d	d) Explain the use of relational conjunctions (and, or) in algebraic arguments.

Table B2. Informational Component of the NAEP Reading Framework

Cognitive Target	Standard	Objective	HumRRO ID
Locate/Recall	Identify textually explicit information (such as definitions, facts, and supporting details) *and* make simple inferences within and across texts.	Identify ***definitions*** within and across texts and make simple inferences.	LR.1
Locate/Recall	Identify textually explicit information (such as definitions, facts, and supporting details) *and* make simple inferences within and across texts.	Identify ***facts*** within and across texts and make simple inferences.	LR.2
Locate/Recall	Identify textually explicit information (such as definitions, facts, and supporting details) *and* make simple inferences within and across texts.	Identify ***supporting details*** within and across texts and make simple inferences.	LR.3
Locate/Recall	Identify textually explicit information (such as, topics sentences or main ideas, author's purpose, causal relations, information in graphics) within and across texts.	Identify ***topic sentences or main ideas*** within and across texts.	LR.4
Locate/Recall	Identify textually explicit information (such as, topics sentences or main ideas, author's purpose, causal relations, information in graphics) within and across texts.	Identify ***author's purpose*** within and across texts.	LR.5
Locate/Recall	Identify textually explicit information (such as, topics sentences or main ideas, author's purpose, causal relations, information in graphics) within and across texts.	Identify ***causal relations*** within and across texts.	LR.6
Locate/Recall	Identify textually explicit information (such as, topics sentences or main ideas, author's purpose, causal relations, information in graphics) within and across texts.	Locate specific information in text or graphics.	LR.7

Cognitive Target	Standard	Objective	HumRRO ID
Integrate/interpret	Make complex inferences within and across texts.	Make complex inferences within and across texts to ***describe problem and solution or cause an effect.***	II.1
Integrate/interpret	Make complex inferences within and across texts.	Make complex inferences within and across texts to ***compare or connect ideas, problems, or situations.***	II.2
Integrate/interpret	Make complex inferences within and across texts.	Make complex inferences within and across texts to ***determine unstated assumptions in an argument.***	II.3
Integrate/interpret	Make complex inferences within and across texts.	Make complex inferences within and across texts to describe how an author uses text features.	II.4
Integrate/interpret	Make complex inferences within and across texts.	Make complex inferences within and across texts to ***summarize major ideas.***	II.5
Integrate/interpret	Make complex inferences within and across texts.	Make complex inferences within and across texts to ***draw conclusions and provide supporting information.***	II.6
Integrate/interpret	Make complex inferences within and across texts.	Make complex inferences within and across texts to ***find evidence in support of an argument.***	II.7
Integrate/interpret	Make complex inferences within and across texts.	Make complex inferences within and across texts to ***distinguish facts from opinions.***	II.8
Integrate/interpret	Make complex inferences within and across texts.	Make complex inferences within and across texts to ***determine the importance of information within and across texts.***	II.9
Critique/evaluate	Consider text(s) critically.	Consider text(s) critically to judge author's craft and technique.	CE.1
Critique/evaluate	Consider text(s) critically.	Consider text(s) critically to ***evaluate the author's perspective or point of view within or across texts.***	CE.2
Critique/evaluate	Consider text(s) critically.	Consider text(s) critically to ***take different perspectives in relation to a text.***	CE.3
Critique/evaluate	Consider text(s) critically.	Consider text(s) critically to ***analyze the presentation of information.***	CE.4
Critique/evaluate	Consider text(s) critically.	Consider text(s) critically to ***evaluate the way the author selects language to influence readers.***	CE.5

Cognitive Target	Standard	Objective	HumRRO ID
Critique/evaluate	Consider text(s) critically.	Consider text(s) critically to ***evaluate the strength and quality of evidence used by the author to support his or her position.***	CE.6
Critique/evaluate	Consider text(s) critically.	Consider text(s) critically to determine the quality of counterarguments within and across texts.	CE.7
Critique/evaluate	Consider text(s) critically.	Consider text(s) critically to ***judge the coherence, logic, or credibility of an argument.***	CE.8

Table B3. WorkKeys Math Targets

Level	WorkKeys Math Targets	ID
3	1. Solve problems that require a single type of Mathematics operation	WKM.3.1
	2. Change numbers from one form to another	WKM.3.2
	3. Convert simple money and time units	WKM.3.3
4	1. Put information in the right order before performing calculations	WKM.4.1
	2. Solve problems that require one or two operations	WKM.4.2
	3. Figure out averages, simple ratios, simple proportions, or rates using whole numbers and decimals	WKM.4.3
	4. Add commonly known fractions, decimals, or percentages	WKM.4.4
	5. Add three fractions that share a common denominator	WKM.4.5
	6. Multiply a mixed number by a whole number or decimal	WKM.4.6
5	1. Decide what information, calculations, or unit conversions to use to find the answer to a problem.	WKM.5.1
	2. Calculate perimeters and areas of basic shapes	WKM.5.2
	3. Look up a formula and change from one unit to another in a single step within a system of measurement or between systems of measurement	WKM.5.3
	4. Calculate using mixed units	WKM.5.4
	5. Divide negative numbers	WKM.5.5
	6. Calculate percent discounts or markups	WKM.5.6
	7. Identify the best deal by doing one- and two-step calculations	WKM.5.7
6	1. Use fractions, negative numbers, ratios, percentages, or mixed numbers	WKM.6.1
	2. Rearrange a formula before solving a problem	WKM.6.2
	3. Calculate multiple rates	WKM.6.3
	4. Look up and use two formulas to change from one unit to another unit within the same system of measurement	WKM.6.4
	5. Find the area of basic shapes (rectangles and circles).	WKM.6.5
	6. Find the volume of rectangular solids	WKM.6.6
	7. Look up and use two formulas to change from one unit in one system of measurement to a unit in another system of measurement	WKM.6.7
	8. Find the best deal and use the result for another calculation	WKM.6.8
	9. Find mistakes in level 3, 4 and 5 problems	WKM 6.9

Level	WorkKeys Math Targets	ID
7	1. Solve problems that include nonlinear functions (such as rate of change) and/or that involve more than one unknown	WKM.7.1
	2. Convert between systems of measurement that involve fractions, mixed numbers, decimals, and/or percentages	WKM.7.2
	3. Calculate volumes of spheres, cylinders, or cones	WKM.7.3
	4. Calculate multiple areas and volumes	WKM.7.4
	5. Set up and manipulate complex ratios or proportions	WKM.7.5
	6. Find the best deal when they have several choices	WKM.7.6
	7. Find mistakes in Level 6 problems	WKM 7.7
	8. Apply basic statistical concepts	WKM.7.8

Table B4. WorkKeys Applied Technology Targets

Level	WorkKeys Applied Technology Targets	ID
3	1. Identify how basic tools work.	WKT.3.1
	2. Identify how simple machine parts work.	WKT.3.2
	3. Apply basic principles to solve problems involving a simple system.	WKT.3.3
	4. Solve basic problems.	WKT.3.4
	5. Identify the clear physical system that points to the potential source of a problem.	WKT.3.5
	6. Identify the best solution after eliminating clearly unsuitable possibilities.	WKT.3.6
4	1. Understand the operation of moderately complex tools and diagnostic equipment.	WKT.4.1
	2. Understand the operation of moderately complex machines and systems.	WKT.4.2
	3. Apply less obvious basic principles to solve problems within physical systems.	WKT.4.3
	4. Solve moderate problems.	WKT.4.4
	5. Eliminate physical symptoms that do not point to the source of a problem, disregarding extraneous information	WKT.4.5
	6. Identify the best solution after eliminating other unsuitable possibilities.	WKT.4.6
5	1. Understand then operation of moderately complex tools and diagnostic equipment, choosing the best tool for the task	WKT.5.1
	2. Understand the operation of complex machines and systems.	WKT.5.2
	3. Apply two or more principles of technology as they interact in moderately complex systems.	WKT.5.3
	4. Solve moderate and advanced problems.	WKT.5.4
	5. Eliminate physical symptoms that do not point to the source of a problem by disregarding extraneous information; use clues to find the source of a problem.	WKT.5.5
	6. Identify the best solution after eliminating other unsuitable possibilities.	WKT.5.6
6	1. Understand then operation of complex tools and diagnostic equipment, choosing the best tool for the task	WKT.6.1
	2. Understand the operation of complex machines and their components.	WKT.6.2
	3. Apply two or more principles of technology as they interact in complex systems.	WKT.6.3
	4. Solve advanced problems where a variety of mechanical, electrical, thermal, or fluid faults could be the reason for the problem.	WKT.6.4
	5. Eliminate physical symptoms that do not point to the source of a problem by disregarding extraneous information; use clues to find the source of a problem.	WKT.6.5
	6. Test possible hypotheses to ensure the problem is diagnosed correctly and the best solution is found.	WKT.6.6

Table B5. WorkKeys Reading Targets

Level	WorkKeys Reading Target	HumRRO ID
3	1. Pick out the main ideas and clearly stated details	WKR.3.1
	2. Choose the correct meaning of a word when the word is clearly defined in the reading	WKR.3.2
	3. Choose the correct meaning of common every day and workplace words	WKR.3.3
	4. Choose when to perform each step in a short series of steps	WKR.3.4
	5. Apply instructions to a situation that is the same as the one they are reading about	WKR.3.5
4	1. Identify important details that may not be clearly stated	WKR.4.1
	2. Use the reading material to figure out the meaning of words that are not defined for them	WKR.4.2
	3. Apply instructions with several steps to a situation that is the same as the situation in the reading materials	WKR.4.3
	4. Choose what to do when changing conditions call for a different action	WKR.4.4
	5. Recognize cause-effect relationships	WKR.4.5
5	1. Figure out the correct meaning of a word based on how the word is used	WKR.5.1
	2. Identify the correct meaning of an acronym that is defined in the document	WKR.5.2
	3. Identify the paraphrased definition of a technical term or jargon that is defined in the document	WKR.5.3
	4. Apply technical terms and jargon and relate them to stated situations.	WKR.5.4
	5. Apply straightforward instructions to a new situation that is similar to the one described in the material	WKR.5.5
	6. Apply complex instructions that include conditionals to situations described in the materials	WKR.5.6
6	1. Identify implied details	WKR.6.1
	2. Use technical terms and jargon in new situations	WKR.6.2
	3. Figure out the less common meaning of a word based on the context	WKR.6.3
	4. Apply complicated instructions to new situations	WKR.6.4
	5. Figure out the principles behind policies, rules, and procedures	WKR.6.5
	6. Apply general principles from the materials to similar and new situations.	WKR.6.6
	7. Explain the rationale behind a procedure, policy, or communication	WKR.6.7
7	1. Figure out the definitions of difficult, uncommon words based on how they are used	WKR.7.1
	2. Figure out the meaning of jargon or technical terms based on how they are used	WKR7.2
	3. Figure out the general principles behind the policies and apply them to situations that are quite different from any described in the material	WKR7.3

Table B6. WorkKeys Locating Information Targets

Level	WorkKeys Locating Information Target	HumRRO ID
3	1. Find one or two pieces of information in a graphic. For example, an individual must find one or two pieces of information (such as a name and phone number) in order to call a sales client.	WKL.3.1
	2. Fill in one or two pieces of information that are missing from a graphic	WKL.3.2
4	1. Find several pieces of information in one or two graphics.	WKL.4.1
	2. Understand how graphics are related to each other.	WKL.4.2
	3. Summarize information from one or two straightforward graphics. The task may involve finding pieces of information and making a general statement about that information.	WKL.4.3
	4. Identify trends shown in one or two straightforward graphics.	WKL.4.4
	5. Compare information and trends shown in one or two straightforward graphics.	WKL.4.5
5	1. Sort through distracting information.	WKL.5.1
	2.Summarize information from one or more detailed graphics.	WKL.5.2
	3. Identify trends shown in one or more detailed or complicated graphics.	WKL.5.3
	4. Compare information and trends from one or more complicated graphics.	WKL.5.3
6	1. Draw conclusions based on one complicated graphic or multiple related graphics. The individual must use higher-order thinking to unravel complicated data and summarize it to form a specific conclusion.	WKL.6.1
	2. Apply information from one or more complicated graphics to specific situations. Given certain, specific criteria, the individual must locate and then determine how to use the appropriate data.	WKL.6.2
	3. Use the information to make decisions. Many workplace responsibilities include using graphics and sorting out unnecessary information to make a decision to solve a problem or complete a task.	WKL.6.3

Appendix C: Webb's Depth of Knowledge and NAEP Cognitive Complexity

Webb DOK (2002)[5]	NAEP Math CCL (2013)[6]	NAEP Reading CCL (2013)[7]
Level 1 (Recall) Requires students to receive or recite facts or to use simple skills or abilities; Includes the recall of information such as a fact, definition, term, or a simple procedure, as well as performing a simple algorithm or applying a formula.	*Low* Students are expected to recall or recognize concepts or procedures specified in the framework.	*Locate and Recall* Students locate or recall information from what they read; identify clearly stated main ideas or supporting details; find essential elements of a story, such as characters, time, or setting.
Level 2 (Skill/Concept) Includes the engagement of some mental processing beyond recalling or reproducing a response; Requires students to make some decisions as to how to approach the problem or activity	*Moderate* Students are expected to decide what to do and how to do it, bringing together concepts and processes from various domains.	*Integrate and Interpret* Students make comparisons and contrasts of information or character actions; examine relations across aspects of text; consider alternatives to what is presented in text.
Level 3 (Strategic Thinking) Deep knowledge becomes more of a focus. Standards and items involve reasoning and planning; Requires students explain their thinking or make conjectures.	*High* Students are expected to use reasoning, planning, analysis, judgment, and creative thought.	*Critique and Evaluate* Students consider the text critically by assessing it from numerous perspectives and synthesizing what is read with other texts and other experiences.
Level 4 (Extended Thinking) Higher order thinking is central and knowledge is deep. The standard or assessment item at this level will probably be an extended activity, with extended time provided; Requires complex reasoning, planning, developing, and thinking most likely over an extended period of time.		

[5] Webb. N.L. (2002). Depth of knowledge levels for four content areas. Retrieved from http://schools.nyc.gov/NR/rdonlyres/2711181C-2108-40C4-A7F876F243C9B910/0/DOKFourContentAreas.pdf

[6] National Assessment Governing Board. (2013b). Mathematics framework for the 2013 National Assessment of Education Progress. Washington, DC: Author. Retrieved from http://www.nagb.org/publications/frameworks.html.

[7] National Assessment Governing Board. (2013b). Mathematics framework for the 2013 National Assessment of Education Progress. Washington, DC: Author. Retrieved from http://www.nagb.org/publications/frameworks.html.