Criterion Referenced Assessment: Delineating Curricular Related Performance Skills Necessary for the Development of a Table of Test Specifications

David MacQuarrie, Ph.D.
Western Michigan University

Brooks Applegate, Ph.D.
Western Michigan University

Warren Lacefield, Ph.D.
Western Michigan University

Abstract

This study focused on defining and delineating core skills and tasks needed for successful CTE student educational growth and success through a curriculum and assessment alignment process. The context for this project lies within Automotive Service Technology (AST), which must additionally meet the National Institute of Automotive Service Excellence (ASE) program certification standards. Unfortunately, two skill areas are not clearly defined or assessed by ASE: Basic Vehicle Interval Maintenance Skills and Basic Vehicle Repair Skills, which combine to form the Automotive Service Technology Foundational Skills (ASTFS). A qualitative analysis of emergent systems patterns was used to construct a table of specifications for ASTFS, which can facilitate curriculum development and assessment. Specifically, this process defined and delineated prerequisite technical skills and their associated ability domains of knowledge, concepts, and skills so they could be taught, learned, and assessed.

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Peter D. Hart Research Associates reports that 40% to 45% of high school graduates are being under-prepared for academics, work habits, as well as for job specific skills required for college or the workforce (2005). The United States Department of Education's Strategic Plan for 2007 to 2012 outlines focused initiatives for educational reform (2007). The third goal of the strategic plan centers on students' successful transitioning between next stage levels: secondary education, post secondary education, and the workforce. Mandated indicators of success have been mandated and schools are expected to improve student's skill levels to prepare the student for their next stage.

Ensuring high levels of student success transitioning from one stage to the next requires alignment of learning materials, learning plans, learner practice activities, and learner assessments with prescribed educational standards (Solution Tree, 2006). Educational accountability is further mandated by the re-authorization of the Elementary and Secondary Education Act (ESEA) of 2001 (more commonly known as the No Child Left Behind (NCLB) Act) and is a common theme that affects everybody (i.e. staff, teachers, and students) in every school and throughout America. NCLB focuses on accountability improvement of graduates' skill levels for either post secondary education or the workforce. Students who possess higher academic and technical skills have more options and a higher probability for success (United States Department of Education, 2003).

Career and Technical Education (CTE) is a nationwide program that emphasizes training for primary, secondary, and post secondary educational stages for the workforce needs of today and tomorrow's society. Although there are many parallels between CTE programs and liberal arts college prep curricula, there are also important differences. The most important difference between college prep and CTE program curricula is the learner outcome. Specifically, many CTE programs focus on academic integration of specific skill standards and tasks and are common language in CTE curricula as much as academic benchmarks are in college prep curricula. Skill standards are typically up-to-date task listings, but can also include program specifications for curriculum, learning materials, the learning environment. In either case, whether addressing standards-based benchmark skills or skill standards in CTE, assumptions are made frequently and possibly inappropriately, regarding prerequisite learner level of content and skills upon entry into the curriculum (Diamond, 1998; Lezotte, 1992; Solution Tree, 2006). One problem that is confounding CTE teachers and learners today is that basic mechanical skills learned in traditional high school programs have disappeared along with those basic programs (Grub & Lazerson, 2004). If prerequisite underlying skills are ignored, assumed, or minimized, teachers‘ will find it difficult for all students in a class to reach desired levels of achievement (Lezotte, 1992). CTE learner outcomes encompass skill sets that often include assessment of skills such as mechanical aptitude, specific job level content, problem solving skills, as well as task achievement. Assessment results for a given skill set can be used to determine students‘ level of preparedness.

Identifying and assessing learner levels for prerequisite content and skills, instead of assuming those levels, allows tailoring of the learning process to individuals and is key to instructional sequencing and planning activities, which help teachers and learners capitalize on their educational growth potential (Diamond, 1998; Lezotte, 1992; Solution Tree, 2006). Identifying and defining prerequisite and underlying skills or tasks requires purposeful analytic techniques (Jonassen,Tessmer, & Hannum, 1999). Automotive Service Technology (AST) tasks are hierarchical in nature and naturally underlie other lower level or predicate tasks that make up a higher level or complex task (Jonassen et al., 1999). For example, if the task is to ask Susan or Johnny to, "Replace the window wiper blade inserts on the family vehicle," this assumes several underlying prerequisite skills or tasks. One underlying task involves knowing the proper tools and parts to use for the job task. Another underlying task would involve knowing or locating the exact procedures and tools to use to replace the wiper inserts. Some other underlying tasks may involve an understanding of when to replace the wiper blades instead of the wiper inserts. Still another lower level set of skills or tasks can be identified such as listening skills, ability to understand locations, and ability to physically coordinate the task steps.

Purpose of the Study

The purpose of this study was to define and delineate skills and tasks relevant to the ASTFS that enable curriculum and assessment development of the ASTFS. Proper assessment design and construction requires that specific content and abilities are very well delineated. To achieve the purpose for this study, objectives that align with typical initial assessment design and construction processes are used.

1. The assessment design and construction processes utilized an assessment purpose and methods to ensure both the content and ability domains were proportionately aligned with a highly recognized content or skill area.

2. The content and ability domains for the ASTFS are delineated and communicated well enough to enable teaching, learning, and assessment of the ASTFS.

Automotive Service Technology (AST) will provide the contextual basis for the processes described in this paper. A second paper following this writing will describe the processes used to make a Criterion Referenced Test using the ASTFS as a context. The purpose of the intended ASTFS Proficiency (ASTFSP) Assessment is to provide a current or prospective AT employee with their proficiency level of the ASTFS as compared to industry criterion levels.

To achieve the objectives of this assessment study several processes were implemented that involve the alignment of skills, curriculum, and assessment. First, a Learning Hierarchical Task Analysis (LHTA) process, as essentially modified from Jonassen, Tessmer, and Hannum (1999), was used to define and delineate the prerequisite skills and tasks from a set of job level tasks. Second, an Analysis Matrix Summary Table (AMST) process, as essentially modified from Bartel's Task Selection Chart Procedure (1976) was used to prioritize and proportion the skills. Third, a Task Domain Categorization Analysis (TDCA) was used to represent the ability domain of knowledge, concepts, and skills to define curricular related teaching and learning objectives. Finally, a Table of Test Specifications was used to represent a balanced assessment plan that could be used for formative or summative proficiency assessments.

METHODS

The first steps in the assessment design process will be to fulfill the first objective, identify the purpose/s of the assessment and align the content ability domain proportions. Assessments can be made to evaluate the progress and proficiency of a group, person, or student in either formative or summative form. Moreover, assessment can be designed to discriminate and separate proficient students from non-proficient students in nearly any employable or educational area regardless of the context. The academic areas that are parallel to CTE are the state high school assessments required by the NCLB Act. These serve as discriminating standards of educational preparedness as well as indicators of success for any given school. High-quality instructional remediation is dependant on well defined skills as well as high-quality formative assessments to evaluate students', teachers, class, or program's performance.

The key to effective assessment of a skill area is the accurate defining and delineation of the underlying, assumed, or prerequisite tasks or skills within the particular educational skill area. Knowledge and skills change with society, time, and technological advances. One example of a training area that is affected by society, time, and technological advances would be in automotive repair (United States Department of Labor, 2006). The quantity and rate of technological advance over the past several decades requires that a do-it-yourself person possess higher skill levels than the average American car owner has. The implications of society, time, and technological advancement indicate that prerequisite skills and tasks need to be redefined and delineated periodically for accurate alignment of curricula and assessments for employment or post secondary education preparation in a particular CTE area.

THE CONTEXT OF A SKILL AREA

The National Institute of Automotive Service Excellence (ASE, 2005) is a nationally recognized organization that assesses and certifies Automotive Service Technology (AST) technicians in eight vehicle system areas: Engine Repair, Automatic Transmission and Transaxle, Manual Drive Train and Axles, Steering and Suspension, Brakes, Electrical and Electronics, Engine Performance, and Air Conditioning. Individually an AST technician can take as many certifications as desired. Surprisingly, not all automotive technicians are required to hold ASE certifications. In fact, many of the individuals employed in "Oil Change" shops may not possess any certification. Instead of certification, "hands-on" On the Job Training (OJT) is relied upon and passed on to the consumer.

In addition to the eight AST systems there are two sets of skills that are not directly assessed by ASE certification assessments. One skill set is core to all eight AST system areas: Basic Vehicle Interval Maintenance Skills (BVIMS). The second skill set corresponds to the underlying skills needed to perform basic vehicle system level diagnostic and repair tasks (eg. Identify and use hand tools correctly) and are collectively referred to as the Basic Vehicle Repair Skills (BVRS). The combination of the BVIMS and BVRS skills together form the set of Automotive Service Technology Foundational Skills (ASTFS).

ASE certified programs are evaluated through a multi-site expert group process and have aligned their AST programs with the standards mandated by the National Automotive Technician Education Foundation (NATEF) (2005). NATEF provides 10 standards that guide the program curriculum, laboratory facilities, program management, and tool and equipment requirements necessary for students to learn the documented list of job level tasks that are called for in an AST curriculum.

The NATEF tasks are nested within one of the eight possible related automotive system areas, which parallel the eight ASE certification test areas. The tasks within any given automotive system area are further nested within their related duty or unit areas. For example the brakes area has seven duty or unit areas and includes: general brake systems diagnosis, hydraulic system diagnosis and repair, drum brake diagnosis and repair, disc brake diagnosis and repair, power assist units diagnosis and repair, miscellaneous (wheel bearings, parking brakes, electrical, etc.) diagnosis and repair, and lastly antilock brake and traction control systems (NATEF, 2008). Surprisingly however, either separately or as a set, the ASE certification exams share a common set of "assumed" skills and knowledge that are not explicitly measured by these exams. Moreover, NATEF leaves it to the instructors and curriculum developers of CTE programs to identify and teach these basic prerequisites.

Tasks are clusters of skills and activities ranging in complexity from lower level simple or underlying tasks to higher level complex tasks (Jonassen et al., 1999). Within the NATEF job level tasks are assumed lower level skills and tasks that are often prerequisite components to those job level tasks. The assumed prerequisite skills that NATEF directly cites as impacting the NATEF system tasks include general skills such as: safety, identification and use of tools and equipment, locating and using reference and training materials (reading and locating information academics), following manufacturers recommended procedures (contextual reading comprehension), storage and use of hazardous materials as outlined by OSHA, and the procedural handling of toxic materials in accordance with EPA and various levels of regulatory government (NATEF, 2008).

The NATEF tasks are arranged by vehicle system areas and are up-to-date, clearly defined, higher level job tasks. However, the assumed prerequisite skills are generalized lower level skills or tasks, which lack clear definition and delineation. Currently a reliable and valid singular assessment does not exist to report a student or technician‘s proficiency or progress level on the ASTFS to allow a proper evaluation of a person‘s preparedness and ability of the ASTFS. A singular assessment for these assumed skills is important to complement existing assessments available for each automotive system through ASE certification tests. An ASTFS assessment could be used to assess a person's proficiency level whether he or she is leaving an AST educational program or upon entry to the AST industry field. Additionally, an ASTFS assessment could be used for program evaluation purposes regarding effectiveness of the teaching and learning environment.

SKILL DOMAIN DISCOVERY PROCESS

To complete the first objective a survey of methods were initiated to discover the process that would serve the delineation process best. The first objective of this study was:

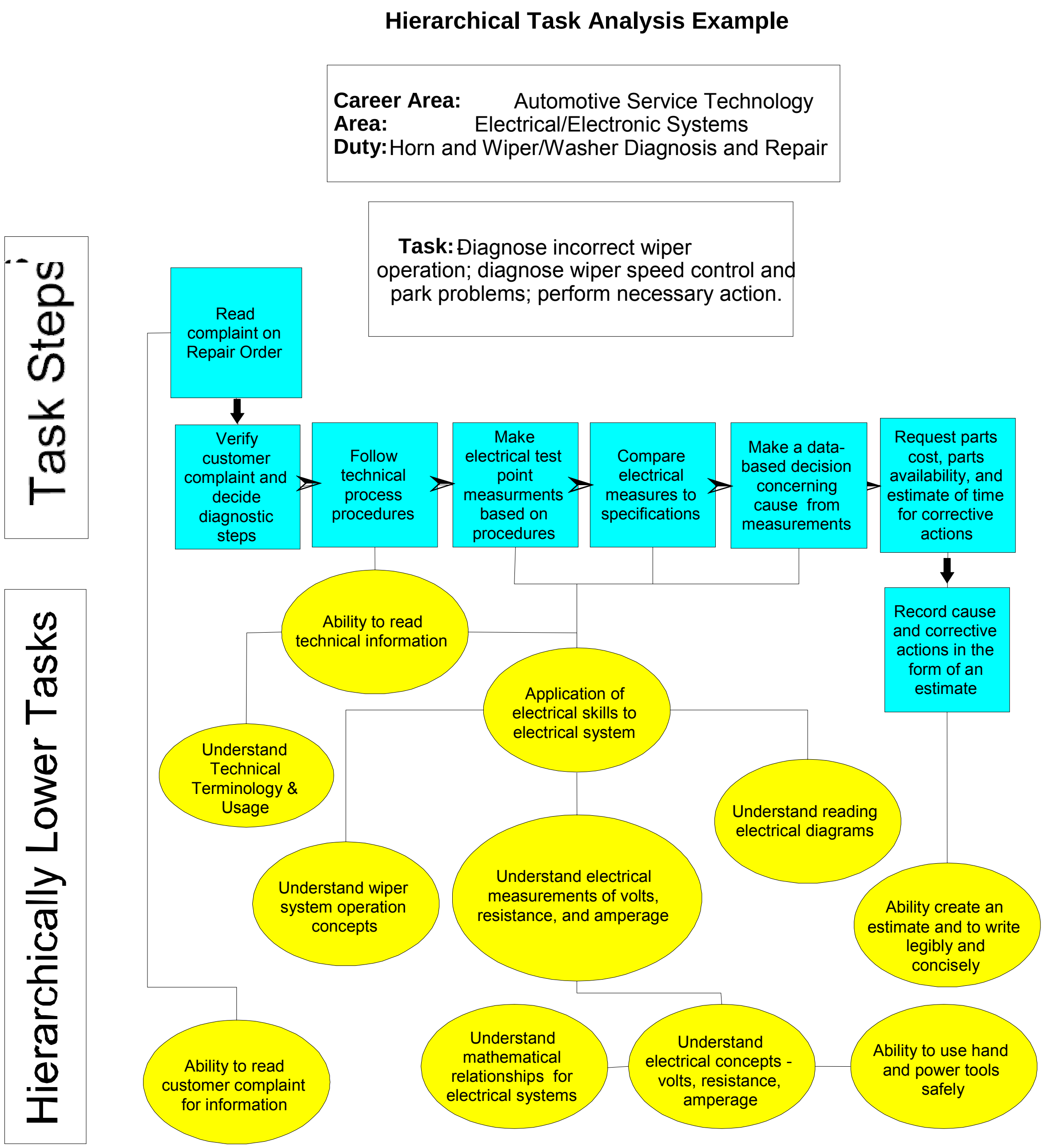
> *The assessment design and construction processes utilized an assessment purpose and methods to ensure both the content and ability domains were proportionately aligned with a highly recognized content or skill area.*

Several methods are available that can be used to define component elements of a complex task. Develop A Curriculum (DACUM) or a common Delphi process uses content experts to identify the job level tasks or elements within a given task (DACUM, 2005). However, if the experts are limited in their knowledge or their understanding of the skill or task area, then the DACUM or Delphi process may not reveal some of the prerequisite skills or tasks required for job level task proficiency. Because there has been a history of automotive skill incompetence documented over the years in common newspapers etc. it doesn't seem a like it would be a good assumption that current Automotive Technicians (AT)'s or AT teachers possess expertise levels of the previously undefined ASTFS. In order to assure that the defined skills are completely delineated, an objective analytical approach was sought. Specifically, the desired logical and objective process selected for the important and essential assumed skills used an analytic qualitative process based on the NATEF supplied tasks by implementing a Learning Hierarchy Task Analysis (LHTA) (Jonassen et al., 1999).

The steps to perform a LHTA listed by Jonassen, Tessmer, & Hannum (1999) include:1) become familiar with the subject, 2) state the task, 3) identify the beginning learner's entry level of knowledge for the task, 4) identify the first level prerequisites, 5) identify second level prerequisites, 6) identify subsequent level prerequisites, 7) determine limit of prerequisite levels of discovery desired, 8) construct the hierarchy of levels, 9) verify the hierarchy logically and empirically. Refer to Figure 1 for a graphical representation of a Learning Hierarchical Task Analysis for an AST NATEF task, which does includes academic content.

Notice in Figure 1 that the career area, task area, duty area, and job level task are labeled in boxes at the top of the diagram. Below the task are eight task steps required to complete the NATEF task. These are delineated from left to right in dark shadowed boxes. Below the task steps are oval boxes that further delineate hierarchically underlying lower levels of tasks, which are linked to task steps. The hierarchical explanation lays in the graphical depiction of the lower oval boxes in reference to the job level task steps, which represents the delineated simpler lower level skills and tasks. The actual tool names are generalized in the graphic boxes because they depend specifically on the year, make, and model of the vehicle being worked on. The skills purposefully excluded in the LHTA for this study were related to academic content, personality traits, and attitudinal constructs such as employability work habits. These skills were considered too broad to be included within a single criterion referenced assessment.

Figure 1. Learning Hierarchical Task Analysis Example



LEARNING HIERARCHICAL TASKS ANALYSIS PROCEDURES

The LHTA referenced almost 400 NATEF tasks for the most common six of the eight system areas. The two areas omitted for this first portion of the LHTA include: Automatic Transmission and Transaxle and Manual Drive Train and Axles. These areas are typically specialized and are dependant on skills from several of the other six NATEF areas. Several strategies were used to make the LHTA process manageable. First, the actual analysis process was completed using a relational database program, which directly referenced the six NATEF task areas. Second, the prerequisite skills and tasks were gathered and sorted into multiple categories for each NATEF task.

An iterative qualitative process of reviewing and comparing the prerequisite skills for the NATEF vehicle system areas, duty areas, and job level tasks allowed several patterns to emerge. These formed the predefined categories related to tool and information type for the initiation of the LHTA process. The nine emergent LHTA categories include: Hand Tools, Power Tools, Special Tools, Shop Equipment, Chemicals, Hazards, Toxic Handling, Safety Procedures, and Other Assumed Tasks. One end product of the LHTA process is a flat sheet report with NATEF tasks in rows by the nine descriptive categories in columns.

Although specific tools and equipment would not be listed in the analysis, it was still necessary to have a defined list compiled during the analyzing process for accurate referencing purposes. Specific tools and equipment were further sorted into various logical sub-types. For example, the hand tools category encompassed nine sub-types and included: general fastener tools, non-threaded fastener tools, general electrical service tools, impact fastener tools, pullers, cleaning tools, cutting tools, threading tools, and last measuring tools. Therefore, the hand tool, power tool, and special tool categories were further defined by listing tools within smaller sub-type categories. AST tool catalogues and AST related text books were researched and referenced for specific information concerning non-vehicle manufacturer specific tools and equipment.

Qualitative data in the form of descriptive information and references to tool or equipment sub-type categories that were appropriate for each of the nine categories were recorded within the relational data base form for each of the nearly 400 NATEF tasks. The skills and tasks as a group made up the BVRS area of the ASTFS. An analytical extraction process was then used to re-sort the redundant qualitative categorical data into either new or existing categories and sub-categories that are more homogenous to the types of skill content instead of the type of tool or information category. Table 1 presents a *crosswalk* of the new category types in relation to the original nine categories.

Table 1 is read as follows: the first of the three sub-scales of tasks for the BVRS scale in the first column, "Oxy-Acetylene Torch Safe Usage." The first task in that particular sub-category is listed in the next lower row of the first column as, "Oxy-Acetylene Torch Set-up." Two X's were recorded under each of two of the nine categories listed in columns 5 and 9 indicating that this prerequisite task relates to shop equipment and safety procedural information. Additionally, column 10 is the category, "Other Assumed Tasks," and includes a worded description for this particular ASTFS task concerning relations to torch usage and safety. This indicates additional and important knowledge and practical skills concerning torch usage that should be specifically included for this task. The balance of the table can be read in a similar manner.

Table 1.
Basic Vehicle Repair Skills Descriptors and Categorization Scheme by Learning Hierarchical Task Analysis Categories

Basic Vehicle Repair Skills sub-scale categories	Hand Tools	Power Tools	Special Tools	Shop Equipment	Chemicals	Hazards	Toxic Handling	Safety Procedures	Other Assumed Tasks
Oxy-Acetylene Torch Safe Usage Scale									
Oxy-Acetylene Torch Set-up				X				X	Torch use and Safety
Oxy-Acetylene Torch Storage				X				X	Torch use and Safety
Oxy-Acetylene Torch Practices				X				X	Torch use and Safety
Mechanical Aptitude & Safe Tool Use Scale									
Pneumatic tools and equipment		X		X				X	
Electrical tools and equipment		X		X				X	
Hand tool selection and use	X							X	Threaded & non-Threaded
Mechanical Aptitude	X							X	Threaded & non-Threaded
Facility Equipment Use and Safety Scale									
Hoists and jack use				X				X	
Fire extinguisher selection and use				X		X		X	
Ventilation				X	X	X		X	
Personal Protective Equipment				X	X	X	X		
Environmental Concerns				X	X	X	X		

During the LHTA re-sorting and crosswalk process, several items (not listed) in the ―Other Assumed Tasks" category did not fit into the new categorical schemes. Thus, a second ASTFS categorical area emerged for these tasks. Research of various manufacturer's service information revealed an existing categorical title for the misfit tasks, which didn't align with the

BVRS category. These misfit tasks in the "Other Assumed Tasks" category are commonly referred to as Interval Maintenance tasks. Therefore, the title for the Interval Maintenance tasks became the Basic Vehicle Interval Maintenance Skills (BVIMS). The categorical area skills in the BVIMS were further sorted into vehicle maintenance interval mileage service time categories, which included: 3,000 to 7,500 mile interval maintenance, 15,000 mile interval maintenance, and 30,000 mile interval maintenance. The end result of the LHTA process was that the ASTFS tasks were sorted into hierarchical categorical scales of skills with the related ASTFS tasks listed under each sub-scale category. Although some manufacturers are changing their interval maintenance category schemes, the maintenance tasks remain stable. The two scale task lists, BVIMS and BVRS, together form the complete ASTFS.

EMPIRICAL VALIDATION PROCEDURES

The next step of the LHTA was to further validate the ASTFS empirically by plotting the ASTFS against all eight of the NATEF areas forming an Analysis Matrix. The Analysis Matrix is a mixed methods process used to empirically confirm the integrity, validation, and verification of the ASTFS content as outlined by Bartel (1976). This process was also used to ensure the alignment of the ASTFS tasks with job analysis information as required by the credentialing standards for measurement (Joint Committee on American Educational Research Association, American Psychological Association, & National Council on Measurement in Education [Joint Committee], 1999). The Analysis Matrix listed the ASTFS tasks in rows with the NATEF duty areas nested within the eight NATEF vehicle system areas in columns. A coding system was utilized to indicate the relatedness of the ASTFS task as either being an underlying task match, a partial task match, an exact task match, or no task match to each of the columns of the NATEF duty areas. An underlying task match is one that is assumed by the job level task implicitly and is not normally described in the repair procedure steps. A partial task match is one that may be described in the procedures and is required to perform the repair procedures and steps. The end result of the Analysis Matrix was a summary table, which contained a set of categorized frequencies for each ASTFS task descriptor, indicating the relatedness and importance of each ASTFS task. Refer to Tables 2 and 3 for a listing of the BVRS area and BVIMS area Analysis Matrix Summary Tables listing the frequencies for each coded area.

The Analysis Matrix Summary Table information for Table 2 is read as follows. The first of three sub-scales listed in column one is the Oxy-Acetylene Torch Safe Usage sub-scale. The first ASTFS task for this sub-category is listed in the row directly below and is labeled Oxy-Acetylene Torch Set-up. The second, third, fourth, and fifth column for the ASTFS task row indicates, respectively, the count of match types where this ASTFS task has either an assumed relatedness, a partial relatedness, an exact relatedness, or no match relatedness concerning the skills needed to proficiently complete the NATEF job level tasks within the NATEF duty area. The second, third, fourth, and fifth column for the ASTFS task sub-category row indicates, respectively, the percent of match types among the ASTFS tasks where this ASTFS task has either an underlying task match, a partial task match, an exact task match, or no task match concerning skill relatedness needed to proficiently complete the NATEF job level tasks within the NATEF duty area. The sixth column for each ASTFS task row indicates the total percentage of all four match types for all 45 duty areas of the eight NATEF areas. The seventh and eighth columns for each sub-category scale row indicate the percentage of matches for each scale and for the sum of the sub-scales together, respectively. The balance of the ASTFS tasks and sub-scales listed in Tables 2 and 3 can be read in the same manner.

In viewing the frequency results it can be noted that the BVRS tasks are mostly an underlying task match in relation to the NATEF tasks and the BVIMS tasks are a partial task match in relation to the NATEF tasks. The percentage of each sub-scale indicates weighting of importance of each ASTFS category and sub-category to the NATEF duty areas as a whole. The percentage weighting can serve as a general guide to the instructional process and plan as well as for assessment guidance and should not be reflective of strict adherence to content. Consideration should also be given to the breadth of complexity within each category. For example the Facility Equipment Use and Safety sub-scale (54.80%) outweighs the Mechanical Aptitude and Tools Use sub-scale (36.87%) in the Analysis Matrix Summary Table percentage results because nearly every repair requires facility use, but not necessarily mechanical aptitude or tool use. However, consider that there are hundreds of tools required in the repair process for the Mechanical Aptitude and Tools Use sub-scale category scale in comparison to the Facility Equipment Use and Safety sub-scale category. The difference in percentage indicates that Facility Equipment Use and Safety sub-scale category is more related (important) to the NATEF job level tasks (54.80%) and is not necessarily a larger or more difficult area of content and skill learning than the other areas. The next step in the process is to further define the ASTFS tasks to reflect recent changes in technology and is expected to change more frequently in time.

Table 2

Analysis Matrix for the 2005 NATEF Areas and the ASTFS Basic Vehicle Repair Skills Scale

Basic Repair Skill Areas	Sub-Scale Areas	Assumed Task Match (*)	Partial Task Match (P)	Exact Task Match (X)	No Task Match	% of Area Match	Percent of Scale
Oxy-Acetylene Torch Safe Usage Sub-Scale	Oxy-Acetylene Torch Set-up	11	0	0		24.4%	
	Oxy-Acetylene Torch Storage	11	0	0		24.4%	
	Oxy-Acetylene Torch Practices	11	0	0		24.4%	
Sub-Total		100.00%	0.00%	0.00%	0.00%		8.33%
Mechanical Aptitude & Safe Tool Use Sub-Scale	Pneumatic tools and equipment	32	0	0		71.1%	
	Electrical tools and equipment	38	0	0		84.4%	
	Hand tool selection and use	41	0	0		91.1%	
	Mechanical Aptitude	35	0	0		77.8%	
Sub-Total		100.00%	0.00%	0.00%	0.00%		36.87%
Facility Equipment Use and Safety Sub-Scale	Hoists and jack use	45	0	0		100.0%	
	Fire extinguisher selection and use	45	0	0		100.0%	
	Ventilation	41	0	0		91.1%	
	Personal Protective Equipment	45	0	0		100.0%	
	Environmental Concerns	41	0	0		91.1%	
Sub-Total		100.00%	0.00%	0.00%	0.00%		54.80%
Total							100.00%

Table 3.

Analysis Matrix for the 2005 NATEF Areas and the ASTFS Basic Vehicle Interval Maintenance Skills Scale

Basic Vehicle Interval Maintenance Skills	**Interval Maintenance Sub-Scale Areas**	**Totals**				**% of Area Match**	**Percent of Scale**
		Assumed Task Match (*)	Partial Task Match (P)	Exact Task Match (X)	No Task Match		
3,000 to 7,500 mile maintenance Sub-Scale:	Change oil and filter	0	0	1		2.2%	
	Lube chassis and drive-train	0	3	0		6.7%	
	Check/Service all fluid levels	0	7	0		15.6%	
	Check/Locate Fluid leaks	0	7	0		15.6%	
	Lube vehicle access features	0	0	0	1	0.0%	
	Check/Service clutch free play	0	1	0		2.2%	
	Check/Service drive belts	0	3	1		8.9%	
	Perform Safety Inspection	0	11	0		24.4%	
	Check/Service tire pressure	0	0	1		2.2%	
	Check/Service all hoses	0	3	1		8.9%	
	Check/Service battery and cables	0	0	1		2.2%	
	Check/Service MIL light, engine, body codes	2	0	0		4.4%	
Totals		4.65%	81.40%	11.63%	2.33%		56.58%
15,000 mile maintenance or One year maintenance Sub-Scale:	All of the 3,000 mile maintenance areas:	0	0	0			
	Check/Service tires and wheels	0	0	1		2.2%	
	Replace air filter	0	1	0		2.2%	
	Check/Service all hoses (Coolant and Vacuum)	0	2	0		4.4%	
	Check/Service cooling system & A/F protection	0	0	2		4.4%	
	Clean radiator externally	0	1	0		2.2%	
	Check/Service tires & wheels (rotate tires/wheels)	0	0	1		2.2%	
	Check/Service emissions filter	0	0	1		2.2%	
	Check/Service brake components	0	6	0		13.3%	
	Check/Service steering and suspension components	0	0	2		4.4%	
	Check/Service vehicle condition (cosmetically)	0	0	0	1	0.0%	

	Maintenance the battery (if applicable)	0	0	1		2.2%	
	Check/Service C.V. joints and suspension	0	2	0		4.4%	
	Lube CV joint boots	0	0	0	1	0.0%	
	Lube door seals	0	0	0	1	0.0%	
	Replace spark plugs (optional)	3	0	0		6.7%	
	Replace air cabin filter	0	0	1		2.2%	
Totals		11.11%	44.44%	33.33%	11.11%		35.53%
30,000 mile maintenance or Two year maintenance Sub-Scale:	All of the items of the 15 K maintenance	0	0	0			
	Flush brake fluid	0	0	1		2.2%	
	Flush auto-trans fluid (optional)	0	3	0		6.7%	
	Flush cooling system	0	0	1		2.2%	
	Replace fuel filter (optional)	0	0	1		2.2%	
Totals		0.00%	50.00%	50.00%	0.00%		7.89%
Total							100.00%

SKILL DEFINITION AND REPRESENTATION

To complete the second objective several additional processes were needed for further delineation for curricular and assessment communication purposes. The second objective was:

> *The content and ability domains for the ASTFS are delineated and communicated well enough to enable teaching, learning, and assessment of the ASTFS.*

A general listing of the ASTFS tasks and categorical group scale and sub-scales serves as a defining and representing guide to the skills domain and are listed in Table 4. General skill listings are ambiguous in comparison to further clarified, defined, and specific descriptions of lower level skills. However, general skill listings are useful for skill presentations as represented for test specifications, area and unit goals, or summary skill explanations. General listings are probably most commonly used in test specifications to ensure proper item proportioning and evidence of content validity. Under the sub-scales are the general outcomes and general objectives used for further defining the skills.

The next step in the representation and defining process is to further define and delineate the ASTFS tasks, specifically with an ability domain. The defining process for each of the ASTFS task sub-scales required researching reputable sources concerning safety and proper procedures from such agencies and organizations as OSHA, EPA, the American Welding Society, Mitchell-One, and specific manufacturer‘s vehicle repair information. The research information provided guidance for further specific defining of each ASTFS task concerning the categories of knowledge, concepts, and skills. The end result of the processes described in the next two sections was a content validated outline of categorized unit outcomes with one to three levels of specific objectives. The specific objectives have been defined and delineated for purposes of curricular alignment, construction of educational materials and instructional lessons, and designing and construction of assessments.

Table 4.
Listing of General Categorical Groups, Sub-Scales, and Outcomes for the ASTFS

010	**Automotive Service Technology Foundational Skills**	
A.	Basic Vehicle Repair Skills	
	1	Demonstrate Oxy-Acetylene Torch Use, Safety, and Maintenance
	a)	Set-up oxy-acetylene torches safely
	b)	Store oxy-acetylene torches
	c)	Practice safe oxy-acetylene torch usage
	2	Demonstrate Mechanical Aptitude & Safe Tool Use
	a)	Select and use pneumatic tools and equipment safely
	b)	Select and use electrical power tools and equipment safely
	c)	Select and use hand tools safely
	d)	Apply Mechanical Aptitude to solve problems
	3	Demonstrate Safe Facility Equipment Use
	a)	Use vehicle hoists and jacks safely
	b)	Select and use fire extinguishers safely
	c)	Practice ventilation precautions
	d)	Understand and practice correct Personal Protective Equipment (PPE) usage
	e)	Demonstrate correct procedures for environmental concerns
B.	Basic Vehicle Interval Maintenance Skills	
	1	Demonstrate 3,000 to 7,500 mile Interval Maintenance Procedures:
	2	Demonstrate One Year or 15,000 Mile Interval Maintenance Procedures (Includes the 3,000 mile maintenance areas):
	3	Demonstrate Two Year or 30,000 Mile Interval Maintenance Procedures (includes the 15 K maintenance items):

TASK DOMAIN CATEGORIZATION ANALYSIS

The Task Domain Categorization Analysis (TDCA) process described is a hybrid process referencing concepts from the AMST created during the AMST process (Jonassen et al., 1999) and from analytic procedures described for curricular alignment (Stiggins, Arter, Chappuis, & Chappuis, 2004; Chapuis & Chapuis, 2002). The purpose of this process is to logically simplify the curricular aligning and defining process to enable further definition and clarity of the skills during the educational preparation process concerning the alignment of: materials via creation and/or selection, learning plans, learner practice activities, and formative and summative assessment creation and design. This step is very important as it ensures the curriculum focuses on ability and not simply content. It is equally important to remember that good assessments, whether formative, summative, or standardized, measure ability of a content area. The TDCA process is performed using a common spreadsheet and a word processing program.

A set of skill ability domain categories defining were chosen to be used in the columns consecutively following the first column. A skill ability domain is typically defined as a continuum that describes depth of ability. It is best to use a domain that is empirically expressed as steps of deeper learning or ability levels such as the commonly referenced Bloom's Taxonomy, with it's three different ability domains: cognitive, affective, and psychomotor (Gronlund & Linn, 1990). Each domain has various stepped levels of ability depth. For example the cognitive domain has six levels of cognitive depth with the following descriptors: knowledge level, comprehension level, application level, analysis level, synthesis level, and evaluation level. However, a simpler post-positivistic taxonomy was sought that would logically represent learners' depth of learning authentically while avoiding the tedious complexity of four or more levels. The traditional classifying categories for a task analysis use knowledge and skills (Jonassen et al., 1999). However, to stay aligned with a goal for this process to be authentically aligned with the CTE areas the categories need to represent cognitive, psychomotor, and affective as they exist in the real world, which is often very complex. The latter classifications seem to be too inclusive and limiting to the sensitivity of the depth of authentic ability. Another proposed categorical system of levels used four "targets" in a continuum and they are: knowledge, reasoning, skills, and product (Stiggins, Arter, Chappuis, & Chappuis, 2004; Chapuis & Chapuis, 2002). However, the latter term "product" does not fit many authentic repair processes, such as those used in automotive service technology. Additionally, the category reasoning seems to fit some academic educational areas better than others so a second option, "concepts," was merged.

In reviewing various learning processes for CTE duty areas and tasks, two different ability domain categories emerged as possibilities for CTE taxonomy. Knowledge level and Concepts, Reasoning, and Problem Solving level remained prevalent for the first two categories of the two possible CTE ability domains for the low and middle ability levels, respectively. The third and highest category of thinking for the two ability domains include: Process Skills, Project, and Product either singularly or in combination. Therefore, the domain ability that included Problem Solving and Process Skills were adapted into the following categorical continuum to fit this CTE area of AST: Knowledge, Concepts / Reasoning, and Problem Solving and Process Skills. This classification continuum is simple, but more complex than a classification task analysis of simply knowledge and skills (Jonassen et al., 1999), and represents classifiable components of content knowledge and the cognitive processes needed to apply a set of authentic skills.

The process was initiated using a spreadsheet with the ASTFS task descriptors listed as rows of the first column. The following three columns were labeled with our three chosen ability domain categories. Additionally, on the right of these columns we labeled three more columns:

Learning Plan & Materials Alignment
Formative Assessment Alignment
Summative Assessment Alignment

These latter three columns would be used by the content educator to label and record educational component titles that reflect the objective learning processes and assessment. Table 5 depicts the TDCA product table for the first sub-scale area of the BVRS with sample materials, learning plans, and learning practice examples inserted. The ability domain categories are the primary distinguishing differences of the TDCA product from a typical curriculum map (Curriculum Designers, 2006).

The descriptive data is entered into the spreadsheet while simultaneously using the word processing software. The word processing software is set up to create a hierarchical outline listing of program of study, area of study, sub area, unit or duty, task, and objectives. Tables 6 and 7 list a sample of the task domain listing of Learning Targets for knowledge, concepts, and process skills for the a sub-scale category of the BVRS in two different formats. Table 6 also lists the slightly adapted, but common and stable hierarchical outline of the ASTFS task descriptors in [parentheses] (Bartel, 1976). It should be noted that the performance level or performance objective was considered equal to a learning target, but was omitted on purpose for the generalizability of the objective concept to allow a teacher to set the level in accordance with their facility and learning parameters.

Table 5.
Sample Task Domain Categorization Analysis for an Area of the ASTFS

Basic Vehicle Repair Skills Sub-Scale Categories	Knowledge Level	Concepts/ Reasoning	Skills	Learning Plan & Materials Alignment	Formative Assessment Alignment	Summative Assessment Alignment
			Oxy-Acetylene Torch Safe Usage Scale			
Oxy-Acetylene Torch Set-up	Know and identify torch components, related terminology, OSHA regulations, and best safety practices	Understand oxidizing chemical reactions, Understand the need for proper torch valve sequencing	Demonstrate torch set-up, cylinder exchange, torch operation, torch shutdown, torch relocating, and torch temporary storage procedures	Text chapter 3 & 4, Oxy-Acetylene Torch Use and Safety Module, Lesson part one	Kagan's show down, Assignment correctives, Laboratory assignment 1 evaluation rubric feedback	Laboratory assignment 1 completion of competency, Unit objective based assessment results
Oxy-Acetylene Torch Storage		Understand the procedures that need to be followed concerning temporary and long-term storage in various conditions	Demonstrate correct and safe torch temporary and long-term storage practices	Text chapter 3 & 4, Oxy-Acetylene Torch Use and Safety Module, Lesson part one	Kagan's show down, Assignment correctives, Laboratory assignment 2 evaluation rubric feedback	Laboratory assignment 2 completion of competency, Unit objective based assessment results
Oxy-Acetylene Torch Practices	Know and identify torch flame characteristics terminology and the relationship between flame color, shape, pressure, and flow	Understand different types of torch flames and related uses, temperature relationships, and limitations.	Demonstrate torch welding and cutting tip, pressure setting, cleaning, and usage procedures	Text chapter 3 & 4, Oxy-Acetylene Torch Use and Safety Module, Lesson part two	Kagan's show down, Assignment correctives, Laboratory assignment 3 evaluation rubric feedback	Laboratory assignment 3 completion of competency, Unit objective based assessment result

Table 6.

Automotive Service Technology Foundational Skills in First Format

Sample Task Domain Listing of Objectives for Knowledge, Concepts, and Skills

1. Automotive Service Technology Foundational Skills [Skill Area]
   - A Basic Vehicle Repair Skills [Sub-Skill Area]
     - 1) Demonstrate Oxy-Acetylene Torch Use, Safety, and Maintenance [Unit or Duty]
       - (1) Set-up Oxy-Acetylene Torches Safely [Skill or Task]
         - (a) I will know and identify torch components, related terminology, OSHA regulations, and best safety practices. [Target]
         - (b) I will demonstrate an understanding of oxidizing chemical reactions and proper torch valve sequencing.
         - (c) I will demonstrate correct torch set-up, cylinder exchange, torch operation, torch shutdown, torch relocating, and torch temporary storage procedures.
       - (2) Store Oxy-Acetylene Torches
         - (a) I will demonstrate an understanding of the procedures that need to be followed concerning temporary and long-term storage in various conditions.
         - (b) I will demonstrate correct and safe torch temporary and long-term storage practices.
       - (3) Practice Safe Oxy-Acetylene Torch Usage
         - (a) I will know and identify torch flame characteristics terminology and the relationship between flame color, shape, pressure, and flow.
         - (b) I will demonstrate an understanding of the different types of torch flames, related uses, temperature relationships, and limitations.
         - (c) I will demonstrate correct torch welding and cutting tip selection, pressure setting, lighting, cleaning, and usage procedures.

Table 7.

Automotive Service Technology Foundational Skills in a Second Condensed Format

Sample Task Domain Listing of Objectives for Knowledge, Concepts, and Skills	
1.	Automotive Service Technology Foundational Skills
1.A.	Basic Vehicle Repair Skills
1.A.1.	Demonstrate Oxy-Acetylene Torch Use, Safety, and Maintenance
1.A.1.1.	Set-up Oxy-Acetylene Torches Safely
1.A.1.1.a)	I will know and identify torch components, related terminology, OSHA regulations, and best safety practices.
1.A.1.1.b)	I will demonstrate an understanding of oxidizing chemical reactions and proper torch valve sequencing.
1.A.1.1.c)	I will demonstrate correct torch set-up, cylinder exchange, torch operation, torch shutdown, torch relocating, and torch temporary storage procedures.
1.A.1.2.	Store Oxy-Acetylene Torches
1.A.1.2.a)	I will demonstrate an understanding of the procedures that need to be followed concerning temporary and long-term storage in various conditions.
1.A.1.2.b)	I will demonstrate correct and safe torch temporary and long-term storage practices.
1.A.1.3.	Practice Safe Oxy-Acetylene Torch Usage
1.A.1.3.a)	I will know and identify torch flame characteristics terminology and the relationship between flame color, shape, pressure, and flow.
1.A.1.3.b)	I will demonstrate an understanding of the different types of torch flames, related uses, temperature relationships, and limitations..
1.A.1.3.c)	I will demonstrate correct torch welding and cutting tip selection, pressure setting, lighting, cleaning, and usage procedures.

TABLE OF TEST SPECIFICATIONS DEVELOPMENT

A Table of Test Specifications (ToTS) provides a blue print for a proposed test construction plan. The ToTS can be used for formal formative or summative proficiency test construction planning. An ability domain is used in the assessment design process to ensure the test is sensitive to ability and that the test taker‘s ability is measured and not simply the test taker‘s knowledge of facts. The following section will describe the process used to design a ToTS for the ASTFSP Assessment. It is noted here that other domains could be used for different types of tests. The ASTFSP Assessment was designed to provide information about a person‘s ASTFS ability concerning cognitive processing in a quick and inexpensive manner and is therefore, a multiple choice paper and pencil assessment. Thus, the domain of choice was similar to that chosen for the TDCA process, but also references Bloom‘s Taxonomy for the cognitive processing domain more closely because a practical performance assessment was considered as being neither practical nor inexpensive. The three domains chosen are: Knowledge, Comprehension, and Application/Analysis levels. These three categories were chosen as they represent the cognitive ability that seemingly parallels those used for the TDCA.

The ToTS process starts by listing the skills in rows and the domain of skills across the columns. The row that follows the last ASTFS task in the sub-scale is labeled as a percentage and will be used to ensure a balance is obtained for each scale and sub-scale. Like-wise the very last row after the final sub-scale row is also labeled as percentage to ensure a balance in planned ability is maintained between each of the domain levels. The desired proportions were decided by several individual content experts after explaining the purpose of the assessment and reviewing the AMST results as well as the goal of the proportions.

After the proportions are decided then the actual test item process will be tracked inside of the table. Inside of the table are proposed item numbers that match the domain as well as the skill for each category and sub-category. The goal of this latter process is to add the items to fulfill the ToTS proportion plan. Refer to Table 8 for a sample of the BVRS Table of Test Specifications.

Table 8.
Sample of the BVRS Scale of the ASTFSP Table of Test Specifications

Basic Repair Skill Area Scale Validity Table	Skill Levels			
Basic Vehicle Repair Skills Sub-Scale Categories	Knowledge Level	Comprehension Level	Application / Analysis Level	Percentage
Oxy-Acetylene Torch Safe Usage Scale				
Oxy-Acetylene Torch Set-up	21, 25	22		12.50%
Oxy-Acetylene Torch Storage		26		4.17%
Oxy-Acetylene Torch Practices		23	24	8.33%
Sub-Scale Percentage of Test Scale Percentage ()	8% (33%)	13% (50%)	4% (17%)	26%
Mechanical Aptitude & Safe Tool Use Scale				
Pneumatic tools and equipment	27	28		8.33%
Electrical power tools and equipment	29		30	8.33%
Hand tool selection and use	31	32		8.33%
Mechanical Aptitude			33, 34, 35, 36	16.67%
Sub-Scale Percentage of Test Scale Percentage ()	13% (27%)	8% (18%)	21% (45%)	44%
Facility Equipment Use and Safety Scale				
Hoists and jack use		37	38	8.33%
Fire extinguisher selection and use	39			4.17%
Ventilation		40		4.17%
Personal Protective Equipment	41, 42			8.33%
Environmental Concerns	43, 44			8.33%
Sub-Scale Percentage of Test Scale Percentage ()	21% (63%)	8% (25%)	4% (13%)	30%
Percentage of Test	41.7%	29.2%	29.2%	100.0%

Discussion, Implications, and Opportunities

General Process Discussion

The process described in this article details a qualitative analytical process for discovering and defining underlying, assumed, and prerequisite skills in the context area of Automotive Service Technology. Additionally, curricular and assessment alignment processes were described for the discovered ASTFS tasks. Context aside, this process could be replicated in almost any educational or career area such as machine trades, construction trades, automotive collision repair, heavy duty truck repair, welding, or other technical areas as the process encompasses a blend of knowledge, skills, and performance. It would make good sense to prepare students for defined and delineated specific level tasks or skills that are aligned with curriculum and internal assessments. High quality internal formative pre-test and post-test practices can guide the teaching and learning process using student feedback as a first stage intervention process. Additionally, a post test that are aligned with the skills of an existing summative assessments, such as state imposed proficiency tests, would allow second stage early interventions prior to actual high stakes testing.

Process Discussion Specific to the Automotive World

The defining, delineating, and development of both the ASTFS and the ASTFSP Assessment can assist schools, AST programs, and employers in evaluating the development level of AT's, prospective AT's, and AST students. AST students would likely benefit from effectively learning the aligned ASTFS skills most if they were to learn them prior to the NATEF task lists as they are underlying skill abilities all AT's would need. Additionally, the ASTFS skills would likely be transferable to many other transportation and industrial areas, making them ideal for career preparation skills. Interested organizations are invited to inquire or volunteer assistance with further research studies.

Curricula and Assessment Alignment to Improve Adequate Yearly Progress

Students that possess higher academic and technical skills have more career and college options and a higher probability for success (United States Department of Education, 2003). NCLB is focused on the accountability of graduates' improvement skill levels for either post secondary education or the workforce. The Performance Measurement Initiative (PMI), mandated by the NCLB, encompasses the accountability of academic as well as Career and Technical Education (CTE) progress of students through assessment (United States Department of Education Office of Vocational and Adult Education, 2005). A CTE program that has aligned their curricula and internal assessments with both valid content and ability domains are likely to improve student learning progress each year as demonstrated on mandated external proficiency assessments.

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