Improving Education, Training and Career Advancement through Competency Portability

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ABSTRACT

"Competencies" – which in this paper include skills, knowledge, abilities, learning objectives, and outcomes – play a fundamental role in education, training and career advancement. This is reflected in the many standardized lists of competencies ranging from occupational standards (MOS and O*Net) and task lists (UJTL) to educational standards (Common Core Standards) and industry standards (NIMS, OPITO, etc.). It is also reflected in the emergence of organizations such as the Competency-Based Education Network (CBEN), and in initiatives sponsored by federal agencies such as the Departments of Labor, Defense, and Education, and the White House.

Nonetheless, competencies are still not managed or exchanged in a standardized or interoperable way. Training systems cannot access lists of competencies through an Application Programming Interface (API), training packages define their own tasks and outcomes rather than use existing ones, and competency-based records of achievement are rarely transportable across military-civilian barriers. The consequences are severe: Jobs go unfilled by qualified unemployed workers (especially veterans) and billions of dollars are wasted because of unnecessary or ineffective training.

Multiple efforts aim to change this. These include standardization efforts, technology development sponsored by the government and by private industry, and government initiatives. This paper provides an overview of competencies, reports on competency-related efforts, and discusses the implications for the training community.

ABOUT THE AUTHOR

Dr. Robby Robson is a researcher and innovator in the broad field of learning technology who has held leadership positions in learning technology standards organizations for almost 20 years and who has contributed to numerous interoperability standards that are widely used today. His work related to competencies began in 1995 with efforts to introduce competency-based education in the State of Oregon and continued with contributions to standards such as the IMS Global Learning Consortium's Learner Information Package and the IMS/IEEE Reusable Definitions for Competencies and Educational Objectives. More recently Dr. Robson has been involved in developing competency management standards and systems for personalized learning and workforce development. Dr. Robson holds a doctorate in mathematics from Stanford University and has contributed to the mathematical literature and literature on learning technology as well as to standards. He is CEO of Eduworks Corporation, which he co-founded in 2001.

A Competency-based Approach to Improving Education, Training and Career Advancement

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1 INTRODUCTION

Competencies (or "competences" as they are called in Europe) have always been important in education, training and career advancement. In work settings, specific skills are required to perform a job, and in educational and training settings, prerequisite knowledge or abilities are required to learn the next topic or succeed in the next class. Until recently, though, the competencies associated with a job, training program, certification, or credential have rarely been made explicit in a way that can be exchanged and consumed by software. Even today the primary means of communicating about jobs, training programs, certifications, and credentials involve job descriptions, catalogs, and résumés that are not cast in terms of competencies.

Although some infrastructure and standardization is needed, there is no significant technological barrier to tracking competencies, issuing associated micro-credentials, replacing résumés with online versions that include validated links to evidence, and managing training and education from a competency and outcomes-based perspective. Nonetheless, this is a relatively new perspective for formal education and for the labor market, and making a change in institutions of that size requires a great deal of motivation. This motivation is coming from two places:

1. In the labor market, employers are overwhelmed with resumes that don't tell them what they want to know about job candidates. Attributes such as grit, leadership and the ability to get along well with co-workers are often differentiating factors in employee success, while jobs often require familiarity with a particular process or piece of software or machinery. None of these requirements is reflected in a transcript or by a certification. In addition, qualifications often include combinations of education, military experience, and on-the-job training that are difficult to evaluate based on a résumé. *The ability for employers to accurately and efficiently recruit and screen candidates is a strong motivator for reporting the results of education, training and work experience in terms of competencies.*
2. The US K-12 educational system has instituted standards that define what students should know and be able to do at various grade levels. These were put in place to address perceived gaps and inequities in student preparation. Colleges and universities did not follow suit. For the most part they have been content with graduating students based on credit hours and course requirements. Now that is changing. Workforce-oriented programs are being pressured to move towards competency-based approaches to meet employer demands, and all of higher education is coming to terms with the ability of students to access courses and programs from multiple online sources and from multiple institutions. *In an environment where students are consumers with choices and in which employers are demanding demonstration of competency, competencies become the common language that can be used to compare educational and work experience and the common currency that students and jobseekers acquire from their education and training and provide to their employers.*

An example of the changes enabled by a competency-based approach is the Department of Veteran Affairs program to enable veterans to more quickly acquire job skills through a combination of training methods that include self-paced and blended learning (VA, 2014). Programs of this nature mix courses from different institutions and attempt to accelerate learning based on knowledge and skills gained on the job. They are not easily implemented without a means to recognize, communicate, and articulate the competencies acquired by a learner in multiple ways from multiple sources. This paper explains how standards for the interoperable exchange of competencies work and describes some efforts that move in this direction. We start by defining what we mean by "competency" and with a review of how competencies are treated by institutions, processes, and technologies today.

2 DEFINITION OF "COMPETENCY"

In training competencies are often defined as knowledge, skills, or abilities (or attitudes), denoted as "KSA," but in general there is no agreed-upon definition (Kennedy, Hyland & Ryan, 2009). As a result it is exceedingly easy to become embroiled in a debate as to whether a learning objective is really a competency, what types of competencies exist (McLagan, 2007), or whether, as is done in O*Net (O*Net, 2015), it makes sense to break down job requirements into other categories such as tasks, tools & technology, work activities, etc. We do not want to enter into this debate, so we consider "competencies" to be a large and somewhat fuzzy bucket that contains KSAs, educational outcomes and objectives, tools and technologies, and many other things characterized by two traits:

1. **Enablement:** A competency enables a person to perform a task.
2. **Observability**: It is possible to observe, test or measure whether a competency is held or has been achieved, i.e. it is possible to gather evidence that estimates a person's competency at a particular point in time.

What matters to us is that a competency is a goal and an asset that affects a person's educational or training experience, career path, and performance. It is therefore acceptable to think of a learning outcome and a skill as both being types of competencies, and indeed the standards that represent one can be equally well used to represent the other.

3 GLOBAL, ORGANIZATIONAL AND LOCAL COMPETENCIES

The meaning and impact of a competency is largely determined by the community that defines and maintains it. Common Core Standards, Military Occupational Specialties (MOS), and O*Net officially define competencies for broad communities of practice. Organizations such as the Manufacturing Skill Standards Council (MSSC), the National Institute for Metalworking Skills (NIMS), and the Offshore Petroleum Industry Training Organization (OPITO) produce lists of competencies that are accepted by an industry. These can be thought of as *global* competencies. Global competencies provide a common language that cuts across all related training programs and job requirements. A major goal of the standards and technology discussed in this paper is to help organizations make use of global competencies and consistently reference them.

3.1 Organizational Competencies

Despite their importance, global competencies usually do not address organizational performance objectives. For this reason, many organizations also define internal lists of *organizational competencies* that drive organizational outcomes (Edgar & Lockwood, 2008). Competencies such as leadership and responsiveness to customers, as well as domain-specific competencies, are common among such lists. Ideally organizational competencies should include global competencies and variations on them so that organizational performance goals are relate to competencies that can be used in a broader context.

3.2 Local Competencies and Competency Portability

It would seem logical for courseware, learning management systems, and talent management systems to be built around global or organizational competencies, but they are not. For historical reasons, many of the processes and technologies used to develop and deliver training scope competencies to a specific training activity or course. They do not have a mechanism to share them across multiple courses, let alone multiple organizations.

In "ADDIE" and other common instructional design processes (Molenda, Pershing & Reigeluth, 1996), the first step is an analysis that identifies learning objectives and tasks. The implicit assumption is that competencies should be defined for each training package by Subject Matter Experts (SMEs) and instructional system designers (ISDs) rather than be drawn from a global set of available competencies that have been defined by others. In other words, ISD processes create what might best be called *local competencies*, a practice which is reflected in the Sharable Content Object Reference Model (SCORM) and therefore by the Learning Management Systems (LMS) that support SCORM.

Specifically, SCORM learning objectives are defined by the SCORM package. When SCORM content is run, the content informs the LMS of the objectives it wishes to track. The implicit assumption is that objectives and competencies are defined differently for each learning activity and that there is no requirement to match them to global or organizational competencies. In addition, the vast majority of military and corporate training is developed using

off-the-shelf authoring tools such as Articulate™ and Captivate™ (Shank & Ganci, 2013). These "rapid eLearning tools" start with the structure and appearance of content and not with learning objectives or competencies, and they cannot reference external lists of competencies; e.g., through an API.

It should be noted that the recently introduced Experience API, or xAPI (ADL, 2015), has the potential to change this by allowing content to report learning activities and results to an intermediary called a "Learning Record Store" (LRS). An LRS can be accessed by any system through web services. Whereas SCORM practically forces competencies to be local, the xAPI can be used to report outcomes in terms of global competencies. Moreover, the xAPI has been adopted quickly by LMS and authoring tool vendors as a SCORM replacement or alternative, which means that one more piece of infrastructure for competency-based training and education is in place. That is good news, but the core problem of referencing global rather than local competencies, and of creating xAPI statements that can be interpreted as validated assertions of competency across multiple systems, still remains.

To summarize, SCORM and related standards and technologies solve the content portability problem for learning content without addressing *competency portability.* In the end it is the competencies that matter.

3.3 Barriers in Higher Education

K-12 instruction and assessment is currently dominated by curriculum standards. Teachers search for resources based on standards, and schools and teachers are judged by how well their students meet those standards. In higher education the situation is different. Financial aid, transcripts, and graduation requirements are defined in terms of credit-hours (i.e., "Carnegie units") and course titles (Silva, White & Toch, 2015). Whereas the completion of a course or degree is evidence of the acquisition of a set of competencies, those competencies are seldom made explicit or recorded. Courses with the same title may cover or test substantially different sets of competencies if offered at different colleges or taught by different instructors. At the degree or program level, completion requirements involve accumulating credit-hours from a menu of courses. Credentials and certificates seldom identify specific competencies achieved.

As things stand, prospective employers must guess what a college credential or certificate really means, and it is very difficult for individuals to receive credit, credentials or certifications based on work or military experience. A well-publicized example of this frustrating phenomenon is the requirement that combat medics go through a complete training program to become a civilian medical professional or Emergency Medical Technician (EMT), even though they likely have acquired and demonstrated many of the required competencies while on active duty (NAEMT, 2012). There are some exceptions. For example, the Accreditation Board for Engineering and Technology (ABET, 2015) has long required engineering students to demonstrate outcomes, and at colleges such as Grand Rapids Community College courses often correspond directly to global competencies. Nonetheless, higher education is still built around seat-time and course titles. Changing this is challenging, not only because it requires a different approach to teaching and curriculum design, but also because credit-hours are baked into federal financial aid programs and graduation requirements.

3.4 Breaking the Impasse

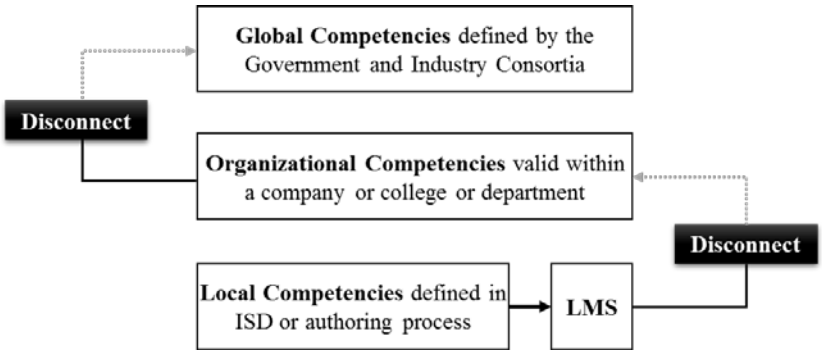

Figure 1: Disconnects affect competency portability

As illustrated in Figure 1, the practical consequences of the situation described above are that data on competencies generated through training activities stays trapped within an LMS or institution. The trainee has no way of using that data to his or her advantage when crossing organizational, military, or vocational boundaries. This impasse can be broken with the adoption of standards and the development of tools that allow the interoperable exchange of competencies and competency-based "transcripts" across multiple systems, institutions, and organizations. The author of this paper has been involved in numerous efforts to create these. A recent effort under the US Advanced Distributed Learning (ADL)

initiative *Personal Assistant for Learning* (PAL) research program has produced an open source competency management services. Another effort, funded by the Thomas R. Brown Foundations, has produced a software design intended to better connect colleges, employers, jobseekers, and workforce support agencies. This work is based on several principles drawn from the study of existing relevant standards and use cases. The next section discusses these principles.

4 PRINCIPLES OF COMPETENCY PORTABILITY

Numerous standards development and other organizations have tackled the problem of representing competencies in ways that can be exchanged by collaborating systems. Examples include:

- The IEEE *Reusable Competency Definitions* (IEEE, 2007) and IMS Global Learning Consortium *Reusable Definitions for Competencies and Educational Objectives* (IMS Global Learning Consortium, 2002).
- The work of Claude Ostyn on "competency maps" (Ostyn, 2006)
- Medbiquitous competency standards (Hersh, Bhupatiraju, et. al. 2006; Smothers, V., 2012)
- The "Integrating Learning Outcomes and Competencies" (InLOC) schema
- The work of the late Dr. Michael Brown on Skill Objects (Brown, Sandall & Landis, 2005) and work done under the auspices of the European TENCompetence project (Koper & Specht, 2007).

These standards share multiple common attributes, which can be ascribed as principles. For example, they all provide a way to assign a unique identifier to a competency and a way to specify a title and description for a competency. These capabilities are also required by use cases that involve the exchange of competencies across collaborating systems. The first principle at work is therefore:

> ***Principle 1 (Persistence):*** *Competency portability requires that competencies be described for human consumption but also be assigned globally unique identifiers (GUIDs) and be retrievable through persistent URLs.*

4.1 Competency Models and Relationships

In general, competencies are collected into sets of related competencies that define an occupation, a task, a set of learning objectives, or the outcomes expected in a specific subject at a specific grade level. These are sometimes called *competency models.* Most of the above standards include a way to identify relationships between competencies and to organize competencies into models or, as they are called in some standards, *frameworks* (Smothers, 2012)

In many settings, these models are referred to as taxonomies, which implies that the models form trees. This is often true of occupational standards and other models (Grant, 2011), but many competency models are directed acyclic graphs (DAGs) but not trees. In training applications, for example, objectives are organized into enabling learning objectives (ELOs) and terminal learning objectives (TLOs) that follow a pre-requisite structure. ELOs and TLOs can easily form structures such as that in Figure 2, in which C1 enables and is a prerequisite for C2 and C3, while both C2 and C3 enable and are prerequisites for the terminal learning objective, C4. This structure cannot be part of a tree.

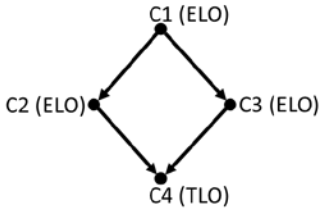

Figure 2: Non-tree relation among competencies

For the purposes of defining pre-requisite or containment among competencies, it suffices to use the "broadens" and "narrows" relationships from the Simple Knowledge Organization System (SKOS) published by the World Wide Web consortium (W3C, 2012). This is the approach taken by Medbiquitous, an accredited standards body that develops information technology standards for healthcare education (Smothers, 2012). But real-world competencies often have imprecise relationships and can relate to competencies in different models. Competency in two programming languages such as C# and Java™ may be related without broadening or narrowing each other, and in real world training programs, ELOs need not be strict prerequisites of a TLO.

When competencies are exchanged it can be important to identify related competencies. The outcomes or competencies explicitly associated with the completion of a course or attainment of a credential are usually the TLOs. An adaptive training system, or an instructor for a different courses, may benefit by knowing what the student has

mastered along the way. In other settings, explicit knowledge of all competencies related to credentials and work experience can be necessary to give proper career guidance. Without such knowledge, a career coach might not recognize that a sailor familiar with enterprise networking would also be familiar with router configuration. For this reason we want to permit competencies to relate to each other in a variety of ways, so the second principle is:

> ***Principle 2 (Relationships):*** *Competency portability requires the ability to describe a variety of relationships among competencies in an interoperable and exchangeable way.*

4.2 Competency Levels

When modeling competencies, one quickly comes across the notion of *levels*. Job descriptions often specify whether a competency must be held at the level of a novice, journeyman or master (or similar set of levels), and many training programs are stratified by level. In a competency model that allows hierarchical relationships, different discrete levels could be represented as distinct but related competencies, but doing so would not accommodate use cases where the levels are continuous; e.g., where a competency is held on a scale of 0 to 1. For this reason the third principle is:

> ***Principle 3 (Levels):*** *Competency portability requires the ability to designate the levels at which a competency may be held.*

4.3 Competency Profiles

Most standards referenced in Section 4 focus on representations of competency models, but the real value to a learner or worker comes from the ability to exchange information about the competencies *they* hold. We call this a *competency profile*. Looked at from the perspective of training systems, the set of competencies that a learner has mastered is part of the learner (or student) model maintained by intelligent tutors and other adaptive learning systems (Woolf, 2009). Methods for the interoperable exchange of learner information are necessary to lower the cost of developing such systems (Robson & Barr, 2013) and to increase training efficiency when trainees engage with multiple such systems. The set of competencies held by an individual is valuable information to employers making hiring decisions, to superiors making promotion and staffing decisions, and to workers making training choices. The fourth principle therefore is:

> ***Principle 4 (Profiles):*** *Standardized methods are needed to exchange information on the competencies held by an individual; i.e., to represent and exchange competency profiles, separate from standards that represent the competencies themselves.*

Unlike systems that store competency models, systems that store competency profiles must contend with privacy concerns and, in educational and research settings, regulations about personal identifiable information (PII). The adoption of standards for competency profiles may also be limited by business interests, e.g., employers may be reluctant to empower individuals to record competencies in ways that could be used by employees when applying to positions elsewhere. Nonetheless, the ability to exchange competency profiles has great value when personnel transition from educational institutions into the workforce or from a military career into a civilian career.

4.4 The Structure of a Profile

Assuming that competency profiles or competency-based transcripts can be maintained and exchanged, what should go into them? In general, there is good agreement that the referenced competencies should be global rather than local. A profile that references a standard military or industry competency has more applicability than one that references a set of competencies whose definitions are known only to a single institution. This leads to the following principle:

> ***Principle 5 (Indirection):*** *A profile should reference competencies externally using a standard rather than just reference local competencies defined in the profile.*

A second point of agreement is that competency can only be estimated. In other words, we can define metrics and measure competence through observations or assessments, but in general we cannot truly know whether a person possesses a certain KSA. Moreover, even if they possess it today, they may forget or lose it over time. Achieving a good score on a test or correctly performing a task may be valid evidence of competence, but it is seldom correct to view the result as absolute proof of competence.

As a consequence, standards for recording profiles can become complex. In addition to identifying which competencies are held (at which level), they should also include ways to

- Express the confidence or probability with which a person holds a competency;
- Identify an authority that has certified a competency;
- Identify evidence used to evaluate or demonstrate competency; and
- Limit the time during which any certification is valid.

Such standards are closely related to standards for badges (Badge Alliance, 2015), which have similar requirements. The following principle, to which we will adhere in this paper, does not cover all of the above nuances but meets the need for time-delimitation and grounding any competency asserted in a profile in some truth or authority:

> ***Principle 6 (Evidence-based Competency Assertions):*** *Any method used to exchange competency profiles must be able to identify by what authority competency is asserted, what evidence was used, and for what period of time the assertion is valid.*

4.5 Traceability

In high stakes training and education settings, the need for Principle 6 is clear. A similar principle is needed for assertions of relationships between competencies, and especially in articulation assertions that equate one course or training program with another. Articulating courses and curricula across institutions is a major headache in higher education (McNeill & Bellamy, 1999; Alexson & Kemnitz, 2003) that is getting worse with the introduction of online options, and articulation is perhaps even more important in training programs. A student who trained on a particular apparatus may be unfamiliar with an important procedure required for a different apparatus or in a different setting. For example, the KSAs for operating a diesel turbine may be different from those for operating a gas turbine. Expressing training outcomes in terms of more granular competencies helps identify articulation issues, but there is still a need to articulate local and organizational competencies across institutions, and in some instances it is important that this articulation be accurate and traceable to a credible authority. For this reason, we add a seventh principle:

> ***Principle 7 (Traceability):*** *Any standard used to represent relationships among competencies must be able to identify by whom and on what basis the relationship was defined. Standards representing competencies should also represent their provenance; i.e., who developed and published them.*

5 PROPOSED STANDARDS

In 2014 the author and his team developed a data model for the ADL that includes the features discussed above and that allows a competency model to point to an external source, i.e., to a global model. This was incorporated into open source software that is currently available on GitHub from the ADL. A more exciting prospect, however, is a standard that that fits into the larger web environment via an effort called *Schema.org*.

Schema.org maintains a set of standards for structured data that can be embedded in web pages used in applications. It is sponsored by Google, Microsoft, Yahoo and others but is an open community project. One of the many schema available through schema.org is the *learning resource metadata initiative* (LRMI, 2015) intended to enable search engines to find learning resources through learning-related properties. Many key metadata elements from Learning Object Metadata (which is used in SCORM) and the Dublin Core Metadata Initiative Education Application Profile (Sutton & Mason, 2001) can be specified as properties of a digital or non-digital resource. The datatype for such resources, *CreativeWork*, includes properties for educational alignment, educational use, interactivity type, learning resource type, and typical age range. It also includes the properties needed to describe the work, specify its provenance, and designate the software required to use it. Of particular interest to us is the "educational alignment" property which takes values in a schema called *alignmentObject* designed to connect a resource to an educational standard. Although focused on educational standards, this same mechanism can be used to associate a resource with a competency.

In 2011 the Chief Technology Officer of the United States started an initiative that resulted in a Schema.org *jobposting* schema. This schema has properties that enable a posting to include educational requirements, qualifications, responsibilities, and skills. These all relate indirectly or directly to competencies. It also has a field for "special

commitments," for which the two examples given are "VeteranCommit" and "MilitarySpouseCommit." As a demonstration of the power of this schema, in November, 2011, the White House launched the Veterans Job Bank and Job Search Widget in collaboration with Google, LinkedIn, Twitter and others based on the *jobposting* schema (Lipowicz, 2011). This allowed veteran-friendly jobs to be identified and found through Linked-In and other searches and illustrates the power of tagging objects in a way that is readily consumed by major service providers.

Although the *jobposting* schema has already had an impact, it was designed to express the data found in standard job descriptions. It allows skills to be expressed, but only as text and not as competencies drawn from an externally maintained list. As the result we have proposed a new *competency* datatype that can be used in *jobposting* and other *Schema.org* schema and a new *evidence* datatype that can be used to associate competencies and evidence with people.

5.1 Proposed Schema.org competency datatype

The most general Schema.org object is *Thing*. *Schema.org* schemas generally start with *Thing* or some other existing schema and add properties specific to the type of object being described.

Much of what is needed to define a competency is already done by *Thing*, including the abilities to assign an identifier such as an MOS or task number, name and describe a competency, and designate a persistent URL for the competency. Even more is done by the *CreativeWork* schema which extends *Thing* and can be used to express properties such as the author, modification date, language, copyright and version of a competency. It can even be used to place a competency in a competency model through the *isPartOf* property. With the addition of a very few properties, shown below, *CreativeWork* can be used to represent competencies in a way that meets the requirements in Section 4:

- *Competency Type* (e.g. KSA, learning objective)
- *Level* (a text or numeric field to accommodate both discrete and continuous levels)
- *relatedCompetency* (Identifies related competencies using a new *CompetencyRelation* type)

***Competency* Datatype Extensions of CreativeWork**

5.2 An Action-oriented View of Relationships and Evidence

The third bullet above refers to another new datatype, *CompetencyRelation*. This datatype is intended to define how two competencies relate to each other; e.g., via relationships such as "broadens," "narrows," "enables," "isEnabledBy," "isEquivalentTo," and even the fuzzy "isRelatedTo." In ontologies and in the semantic web, such relationships are viewed simply as statements, but to follow Principle 7 in Section 4, we must also represent by whom and on what basis a relationship is asserted. The same is true for representing evidence.

Schema.org can be used to do this in an elegant way via its *Action* datatype. In this representation, we think of a relationship among competencies and an assertion of competency as the *result* of an action. The *Action* datatype can then be used to record this result, who performed the action, what was used to perform it (the evidence), when it was performed, and its status. The status property can take on three values: One indicates that the evidence was completed, one indicates that the evaluation of evidence is in progress, and one indicates that the evidence *could* be used to evaluate competence. This latter status enables tests, for example, to be associated with the competencies they evaluate without requiring that they be administered to any individual.

5.3 Resource Alignment

A use case that has not been discussed is that of aligning training resources with competencies. This is important for repositories of learning objects. The Department of Labor, for example, has funded the Multimedia Educational Resources for Online Teaching and Learning (MERLOT) project to create a repository called *skills commons* of all materials produced under the multi-billion dollar Trade Adjustment Assistance Community College and Career Training (TAAACCT) program that funds community college programs and curriculum development. These must all be tagged with associated skills and competencies. In K – 12, teachers look for resources based on the common core (or similar) standards they address.

Our proposed approach for aligning resources with competencies is to extend the LRMI *AlignmentObject.* The LRMI *AlignmentObject* includes properties for the type of alignment (e.g., "assesses" or "requires"), an educational

framework (e.g., Common Core or California's Next Generation Science Standards), and targets within that framework. Although intended for educational standards, it can be used equally well for competencies of any sort.

6 NEW WAYS OF DEFINING COMPETENCY MODELS

The work presented so far in this paper assumes that competencies are defined by authorities or by SMEs and ISDs. This assumption bears examination in light of the larger Internet trend away from authoritative, explicit structures to crowdsourced, dynamically generated classifications.

The traditional means for defining competencies is to engage relevant experts, whether the goal is to define local competencies as is done in ADDIE, industry standards for certification, or educational outcomes for use in evaluating students and schools. This authoritative, top down approach has the advantage of reflecting the beliefs of an expert community of practice, but has disadvantages as well.

One disadvantage is speed. Convening or polling experts is a slow and expensive process. O*Net, for example, gathers its data using industry surveys. Although this method is dictated by Office of Management and Budget (OMB) Information Quality Guidelines (IQG), O*Net has been criticized because its data is not refreshed frequently enough. Another disadvantage is that experts have difficulty reaching consensus and may have trouble keeping up with the rapid changes that are occurring in professions such as information technology, advanced manufacturing and health care or with rapidly changing tactics or strategies used by hostile forces in military settings.

Today, alternative approaches for defining competency models are available. Linked-In, for example, has developed a folksonomy of skills that appear as Skills & Endorsements in a Linked-In profile. Several companies – including Burning Glass, Economic Modeling Specialists International, and Geographic Solutions – scrape tens of thousands of job postings to produce what is called Labor Market Information (LMI). The data they collect are provided to the federal government and are used by states to display how many jobs of a particular type are open in a particular region. The same data can be used to determine which competencies are mentioned in thousands of job postings for a particular job title. The ability to exchange competency models in a standardized way, as proposed in this paper, opens up the possibility of mining locally defined models for common themes and collating hundreds or thousands of locally defined competencies into dynamically updated global model. Crowdsourced models of this nature could expected to be relatively stable and might more accurately reflect training requirements and employer requirements than the authoritative models used today.

7 CONCLUSIONS

Competencies are the building blocks and can serve as the currency of learning, education, training and workforce development. Organizations such as the Competency-Based Education Network (CBEN, 2015) and Government agencies including the Departments of Education, Labor and Defense are in various ways promoting an agenda that includes a competency-based approach. Proper use of competencies can enable better articulation across learning and training experiences, make it easier to cross military-civilian and education-workforce barriers, and lead to more efficient and effective training methods.

As has been pointed out by many authors, standards are needed to enable collaborating technologies to effectively exchange competencies and competency profiles in an interoperable manner (Grant & Rowin, 2010). This paper describes principles for such standards and outlines how those principles can be incorporated into standards based on *Schema.org*. A version of these proposed standards is used by open source technology for managing competencies, competency models, and competency profiles, available from the ADL GitHub (Brown et. al., 2015). This technology supports JSON web services that other applications can use to manage and share competency models and profiles. It also uses the xAPI for exchanging statements about competencies with other applications, as was envisioned when the xAPI was developed (Murray & Silvers, 2013).

It seems inevitable that competencies will someday be managed independently of any given learning technology that learning activities will be able to reference global competencies and not be bound to local competencies as is the case in SCORM. We are very much looking forward to that day.

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