An Ontology for Open Rubric Exchange on the Web

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Abstract

While the Internet has given educators access to a steady supply of Open Educational Resources, the educational rubrics commonly shared on the Web are generally in the form of static, non-semantic presentational documents or in the proprietary data structures of commercial content and learning management systems.

With the advent of Semantic Web Standards, producers of online resources have a new framework to support the open exchange of software-readable datasets. Despite these advances, the state of the art of digital representation of rubrics as sharable documents has not progressed.

This paper proposes an ontological model for digital rubrics. This model is built upon the Semantic Web Standards of the World Wide Web Consortium (W3C), principally the Resource Description Framework (RDF) and Web Ontology Language (OWL).

Keywords

rubric, ontology, open educational resources, Semantic Web

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Benefits of Rubrics

Much attention has been paid in recent years to the effectiveness of rubrics in fostering a more level, efficient and scalable educational experience. Rubrics serve as "the criteria for a piece of work, or 'what counts'" (Goodrich, 1997) during the assessment or evaluation of a student work, activity, or artifact. They can be a powerful aid to educators in communicating their expectations to learners.

Traditional educational assessments, such as quizzes, seek to evaluate a student's retention of knowledge rather than a "student's ability to apply skills and knowledge to real-world problems." (Marzano). This effect becomes more pronounced in high enrolling courses regardless of the delivery method (online, blended, or face-to-face) due to difficulties of scaling up these methods.

Rubrics offer a unique opportunity to replace these traditional assessment methods with projects and creative assignments. These *authentic assessment* activities (Rocco) enable students to learn through direct application of concepts. Tierney & Simon found rubrics "especially useful in assessment *for* learning because they contain qualitative descriptions of performance criteria that work well within the process of formative evaluation." By understanding the benefits of rubrics from both the student and instructor perspective we can begin to examine the individual elements of rubrics and how we can best utilize them in education.

Assessments based on students' knowledge retention from lectures and course readings often provide limited guidance or focus on what information is most important. In this format nearly all of the information may appear to have a significant value depending on an individual perspective or interpretation. Rubrics have the ability to clarify the learning objectives and guide students toward meeting the predetermined objectives through meaningful activities.

Rubrics also enable instructors to more clearly communicate their expectations to students by identifying the criteria required to obtain a certain level of success. Andrade (2000) posited that we "often expect students to just *know* what makes a good essay, a good drawing, or a good science project, so we don't articulate our standards for them." By not establishing criteria or standards for an assignment, students are forced to push blindly forward seeking unidentified milestones that may not even exist until the first project is graded.

In a similar manner, rubrics also have the ability to normalize subjective assignments. If no criterion has been identified for students, they often associate or establish their own standards based on previous experiences. "In comparing criteria mentioned by students, I found that students with no experience with rubrics tended to mention fewer and more traditional criteria. Students who had used rubrics tended to mention the traditional criteria, plus a variety of other criteria—often the criteria from their rubrics." (Andrade, 2000) When presented with any type of evaluative task students strive to establish some type of construct to inform their creation process which may or may not align with the instructors intent. In a similar manner, students will have different perceptions of what type of criteria is required for a passing grade. Through the inclusion of rubrics, students are provided with a set of standardized goals, which enables them to focus on the creation of the project rather than trying to determine the instructor's intent.

Once a consistent and reliable set of criteria has been established, the students can then utilize the rubrics as a form of self-assessment. Students can learn to evaluate their work while referencing

the rubric. This enables them to identify the gaps or weak areas of their projects prior to submitting it for an instructor review, thereby instilling valuable self evaluation skills. Instructional rubrics provide students with more informative feedback about their strengths and areas in need of improvement than traditional forms of assessment do. (Andrade, 2000) The use of rubrics enable students to achieve the standards set forth by the instructor, in addition to learning how to review and revise their own work.

In addition to providing educational benefits for students, rubrics also have the ability to significantly impact an instructors ability to grade assessments. Once an instructor has established a scoring rubric, it can be duplicated and adapted to address variances in assignments. This allows assignments with similar attributes to share a base set of standards, yet allowing for the individual differences to be addressed. For scoring rubrics to fulfill their educational ideal, they must first be designed or modified to reflect greater consistency in their performance criteria descriptors. (Tierney & Simon) Rubrics can also serve as a standard measure across course sections, ensuring all instructors or Teaching Assistants assign grades based on a shared standard.

While a main purpose of rubrics is to set forth an established and standardized set of criteria to benefit students, rubrics also have the ability to significantly impact an instructors' effectiveness when teaching high-enrollment courses. Rubrics can assist instructors in the following ways:

- Ensure a *consistent* grading scale across all course sections, enabling all instructors or Teaching Assistants to assign grades based on a shared standard.
- Allow the instructor to *efficiently* review a student's work by select the appropriate level of accomplishment, while respecting the instructors limited time.
- Reduce grading time by assigning the standardized criteria to students projects which enables the instructor to provide additional *customized* responses to the submissions
- Provide *scalability* by decreasing grading time enabling instructors to take on a greater number of students with less of an impact on their teaching load.

Rubrics and the Internet

With all the benefits to the educational process provided by rubrics, it should come as no surprise that a wide variety of rubrics can be found on the Internet. Many educational institutions, from primary schools to universities, publish collections of rubrics created or used by their faculty.

This quantity, however, is not of equal quality: "The most accessible rubrics, particularly those available on the Internet, contain design flaws that not only affect their instructional usefulness, but also the validity of their results." (Tierney & Simon) In many cases, Internet rubrics provide only rough scoring guidelines, and lack the specificity of feedback to provide real value to the learning experience, thereby failing both the educator and the learner.

In addition, most available rubrics are in a *presentational format* – typically a visual representation meant for human consumption. Examples include:

- *Documents* – Microsoft Word, Portable Document Format (PDF)
- *Spreadsheets* – Microsoft Excel
- *Non-semantic Web pages* – HyperText Markup Language (HTML)

While generally quite usable, presentational format rubrics are ill suited for inclusion as part of an interactive software system. Such systems will be unable to use these rubrics to mediate grading activities until it has been converted to the system's own internal format.

Software tools to facilitate creation of rubrics are also plentiful. A survey of these tools reveals that most produce rubrics in *proprietary semantic representations* that are not open and transferable between systems. These representations are different for each system and are used internally to manage the storage and retrieval of the data and metadata. On-line tools such as RubiStar (ALTEC, 2010) and the Rubric Machine (Warlick & The Landmark Project, 2010) are examples of this. While both systems are fairly easy to use and provide large libraries of existing rubrics, they provide only limited output formats for documents. Anyone wishing to transfer the rubrics they create with these tools to another system, such as an LMS, must re-create the rubric in the new system or transfer it in a presentational format (e.g. PDF, HTML). In addition, some of the more advanced systems, such as ANGEL Grading Rubrics (ANGEL Learning, 2010) and Rubrix (Discovery Software, 2010) charge significant licensing fees for their use, making a proprietary data model even less desirable.

What is needed is an open, non-proprietary way of describing rubrics for both machine and human use.

Enter The Semantic Web

In order to meet the requirement of an open representation for rubrics in software systems, we must have a means of describing the entities, components and relationships present in the education knowledge domain. This set of ideas forms the *conceptualization* of the domain. By explicitly describing this conceptualization in a formal way we create an *ontology*. (Gruber, 1993)

While many frameworks exist for specifying ontologies, two complementary frameworks have been by the World Wide Web Consortium (W3C) as Semantic Web Standards. These frameworks are the Resource Description Framework (RDF) and Web Ontology Language (OWL). OWL 2.0 (World Wide Web Consortium [W3C], 2009) represents the state of the art for the creation of open ontologies and is a superset of RDF (W3C "RDF Concepts and Abstract Syntax", 2004). Information described in OWL can be consumed and manipulated a large number of software packages and libraries.

By using OWL to describe our ontology we can also leverage the growing number of existing RDF and OWL vocabularies to describe aspects of our data model not central to the rubric domain. Some excellent examples of existing ontologies that complement our rubric ontology are:

- *Friend-Of-A-Friend (FOAF)* - a vocabulary for describing people, such as creators and users of rubrics (Brickley & Miller, 2010)
- *Dublin Core Metadata Initiative (DCMI)* - a popular system for describing metadata for digital assets (DCMI, 2010)
- *Creative Commons* - for denoting the rights granted by the creator of digital assets to their users (Creative Commons, 2010)

The ePortfolio Ontology (Wang, 2009) is another good example of a complementary ontology. It models the various entities in a student ePortfolio system, including a minimal *Rubric* entity. We

can use this *Rubric* as an integration point to allow systems built on that model to leverage rubrics created according to our ontology.

While a thorough introduction to OWL and RDF is beyond the scope of this paper, we will touch on some aspects of OWL and RDF in the next section when necessary to shed light on the rubric ontology implementation.

Overview of The Rubric Ontology

The key entities in the rubric ontology are: *Rubric*, *Criterion*, *Level*, and *Category*. Two more entities, *Scope* and *Scoring*, indicate the intended application of the rubric by users and software systems. Figure 1 shows a simple UML class diagram detailing the basic relationships between these key entities.

Rubric

The central entity of the rubric ontology is naturally the *Rubric*. A review of the literature around use of rubrics has identified at least three distinct subtypes of rubrics:

- *Analytic* – analytic rubrics break down the assessment or evaluation of a work into discrete criteria. These criteria are generally tied back to the learning objectives of the unit or course. (Rocco) Each criterion is further broken down into levels of achievement, from minimal to exemplary.
- *Holistic* – Holistic rubrics are used to assess "the whole of a process, performance, or product" (Rocco). This type of rubric is used when criteria overlap or are otherwise hard to isolate.
- *Primary Trait* – Similar to the analytic rubric, the primary trait rubric "describes in detail what is required for performance" (Rocco). Rather than breaking down to discrete levels, a free-form evaluation or assessment is made for each criterion. A variant, the *scoring guide rubric*, is found in several sources, including (Stevens and Levi)

Analytic rubrics are by far the most common subtype in online rubric repositories. They also appear to be the most regular form of rubric in structure. The only significant variation found was whether the number of levels per criterion was uniform (making the rubric a regular grid or table) or variable (some criteria possessing a finer or rougher gradation of scoring).

In contrast, holistic rubrics varied widely in appearance. Some seemed to be nearly identical to analytic rubrics, differing only in their wording and intended use (Rocco), while others were very different. (Bargannier, Mertler).

Criterion

The main building block of the analytic and primary trait rubrics is the *Criterion* (plural *Criteria*). Each *Criterion* represents a focused "part of the task". (Stevens and Levi). In the grid form of the analytic rubric, each row of the grid corresponds to a criterion. While we chose Criterion as the canonical name for this element, it is called a *dimension* in at least one source (Stevens and Levi). In our opinion this is merely a symbolic variation and not a semantic difference between conceptualizations.

Level

The *Level* is the main component of the *Rubric class* in a holistic rubric, and of *Criteria* in analytic rubrics. The set of *Levels* should prescribe the range of assessment outcomes, from a low achievement (e.g. "poor" or "incomplete") to high achievement (e.g. "exemplary"). The columns of a tabular analytic rubric generally correspond with the *Level* entities. Similarly, the rows of a holistic rubric will generally map to *Levels*.

Category

Categories are simple containers to aggregate multiple sequenced *Criteria.* We generally found categories in large or complex analytic rubrics. *Categories* can also play a useful role in software user interfaces based on rubrics. The Faculty Self-Assessment Tool from Penn State (Panulla, Rocco and McQuiggan, 2008) places the Criteria within a given Category in the same section of an accordion control (See Figure 2).

Scope

The *Scope* of a rubric is meant to indicate what the rubric's creator intended to assess or evaluate. The current ontology defines four distinct scopes:

- *Individual* – used by a teacher or educator to assess or evaluate the work of a single individual learner.
- *Team* – used by a teacher or educator to assess or evaluate the work of a group or team. Team rubrics are commonly found in *Problem-Based Learning (PBL)* environments.
- *Peer* – used by one individual learner to evaluate or assess the work of another individual learner. Peer rubrics are also common in PBL environments; teammate evaluations may play a role in an overall course participation grade.
- *Self* – used by an individual to assess his or her own learning or development.

Specifying the intended Scope of a rubric can provide two powerful advantages:

- Search systems may filter results from a database of rubrics, eliminating those created for a different purpose than the one desired.

Software systems may use the Scope to identify how it should present the rubric to the user in different contexts. For example, a secure online Peer-Review system with knowledge of course group assignments may allow students to securely and privately evaluate the other members of their team via a rubric, while preventing other students from seeing or affecting those evaluations.

Scoring

The *Scoring* attribute of a rubric allows creators to create both *scored* and *unscored* rubrics. While *scored* rubrics are likely to be the norm, educators sometimes find it desirable to assess a student's learning progress without having it directly impact their grade. It is expected that software systems displaying *unscored* rubrics should still provide qualitative feedback to the learner.

Artificial Entities

As with any computerized representation of an information model, there are several entities introduced into the rubric ontology by the idiosyncrasies of underlying technology.

It can be difficult to maintain closed, explicitly ordered lists of items in the present version of OWL. While the RDF Schema specification (W3C "RDF Vocabulary Description Language", 2004) does define several Collection classes for aggregation, these classes do not provide semantics for restricting their contents to given classes of entities.

To get around this problem and strictly model lists of Criteria and Levels we have defined two additional entities: CriteriaList and LevelList, based off the RDF List Collection.

Future Goals

Holistic Rubrics

The model of holistic rubrics is somewhat incomplete. While a holistic rubric may be modeled superficially using the existing entities in the ontology, a more thorough explanation of the use and intent of holistic rubrics may ultimately lead to a different data model.

Improved List Modeling

The use of RDF Lists in OWL ontologies results in the ontology being validated as OWL-Full (W3C, 2009). Reasoning over OWL Full ontologies cannot be guaranteed to be finite or even efficient. Consequently, it is a best practice to avoided models that push into the OWL-Full realm. It may be possible to replace the RDF Lists-derived classes in the rubric ontology with an alternate model that allows validation as OWL DL without a significant loss of compatibility or semantic expressiveness.

Implementations

At present, three systems are under development at Pennsylvania State University that can create and/or consume rubrics described according to this ontology:

- The Faculty Self-Assessment tool (Panulla, Rocco and McQuiggan, 2008) was the prototype application in which many of the ideas captured in the current version of the ontology were developed.

- The Assignment Studio Rubric module for Drupal (Bailey and Ollendyke, 2009) is used at Penn State University's College of Arts and Architecture to manage course activities in several resident and hybrid courses. An updated version of this module for Drupal 7 that incorporates this rubric ontology is currently in the design phase.

A Rubric Builder Rich Internet Application (RIA) is currently under development for Spring 2011. The Builder provides a rich, easy to use interface that captures many of the best practices of rubric design and guides the user to produce better rubrics

Figures and Tables

Property	Description
title	Title of rubric
description	Free-text description of intended use.
hasScope	See Scope and Scoring below.
hasScoring	See Scope and Scoring below.
hasCriteria	Set of criteria/categories (mainly Analytic Rubrics).

Table 1: Properties of Rubric class

Property	Description
title	Title of criterion
description	Free-text description of meaning of criterion.
weight	Weighting factor for scored rubrics
hasLevels	Set of levels (mainly Analytic Rubrics).

Table 2: Properties of *Criterion* class

Property	Description
benchmark	Text describing characteristics of this degree of achievement. Can have one or more per level.
quality	A qualitative description of this degree of achievement. Used for column headers in tabular rubrics
score	The points awarded for achieving this level.
feedback	Pre-defined feedback text to be relayed to the learner; may include guidance and suggestions for improvement or development.

Table 3: Properties of *Level* class

Property	Description
title	Title of category.
hasCriteria	Set of criteria/categories (mainly Analytic Rubrics).

Table 4: Properties of *Category* class

Class	Description
CriteriaList	Contains Criterion and Category instances in explicit order. Category instances contain an additional CriteriaList, resulting in a tree structure of Categories and Criteria.
LevelList	Contains Level instances in explicit order.

Class	Description
CriteriaList	Contains Criterion and Category instances in explicit order. Category instances contain an additional CriteriaList, resulting in a tree structure of Categories and Criteria.
LevelList	Contains Level instances in explicit order.

Table 5: List classes

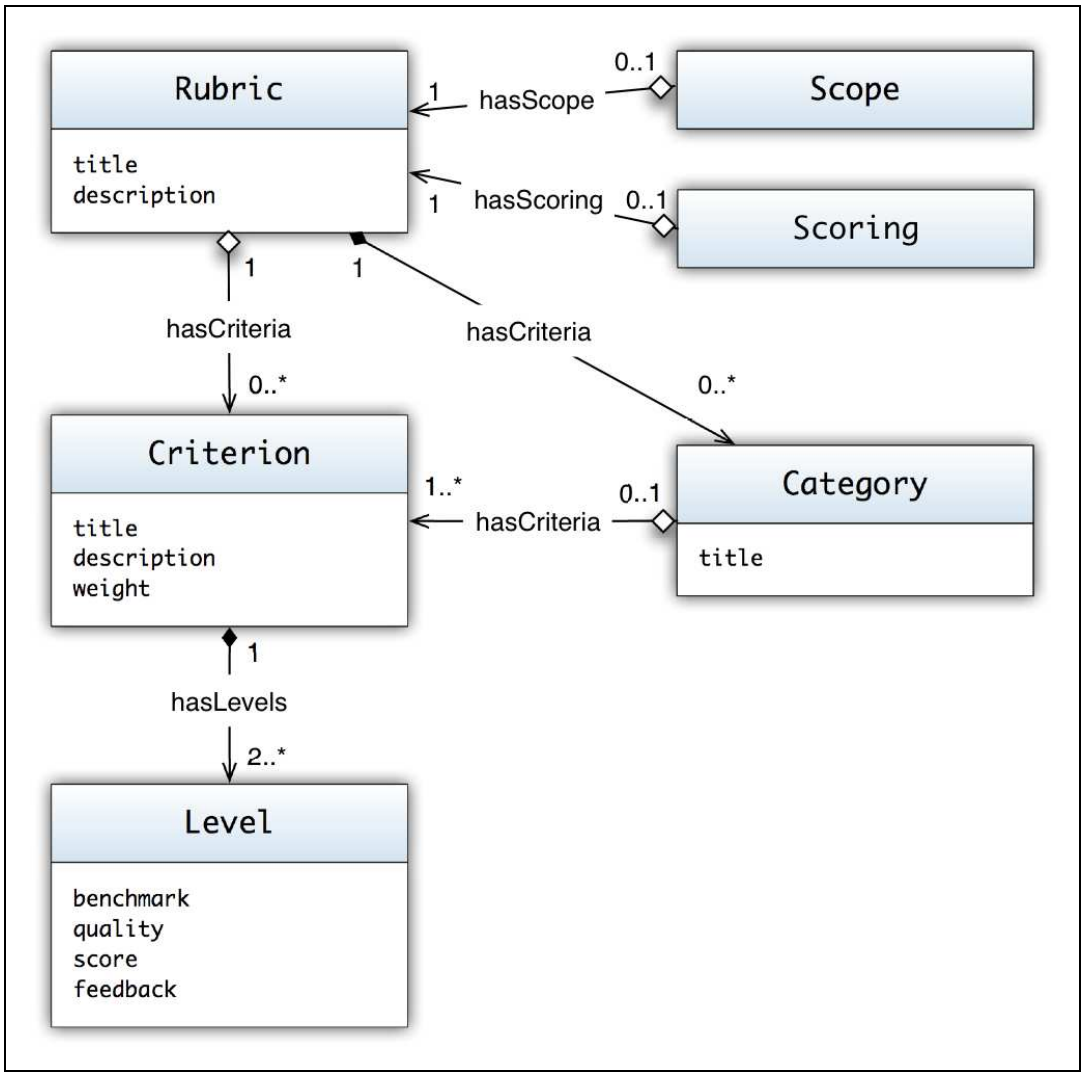

Fig. 1 – Simplified Rubric UML model

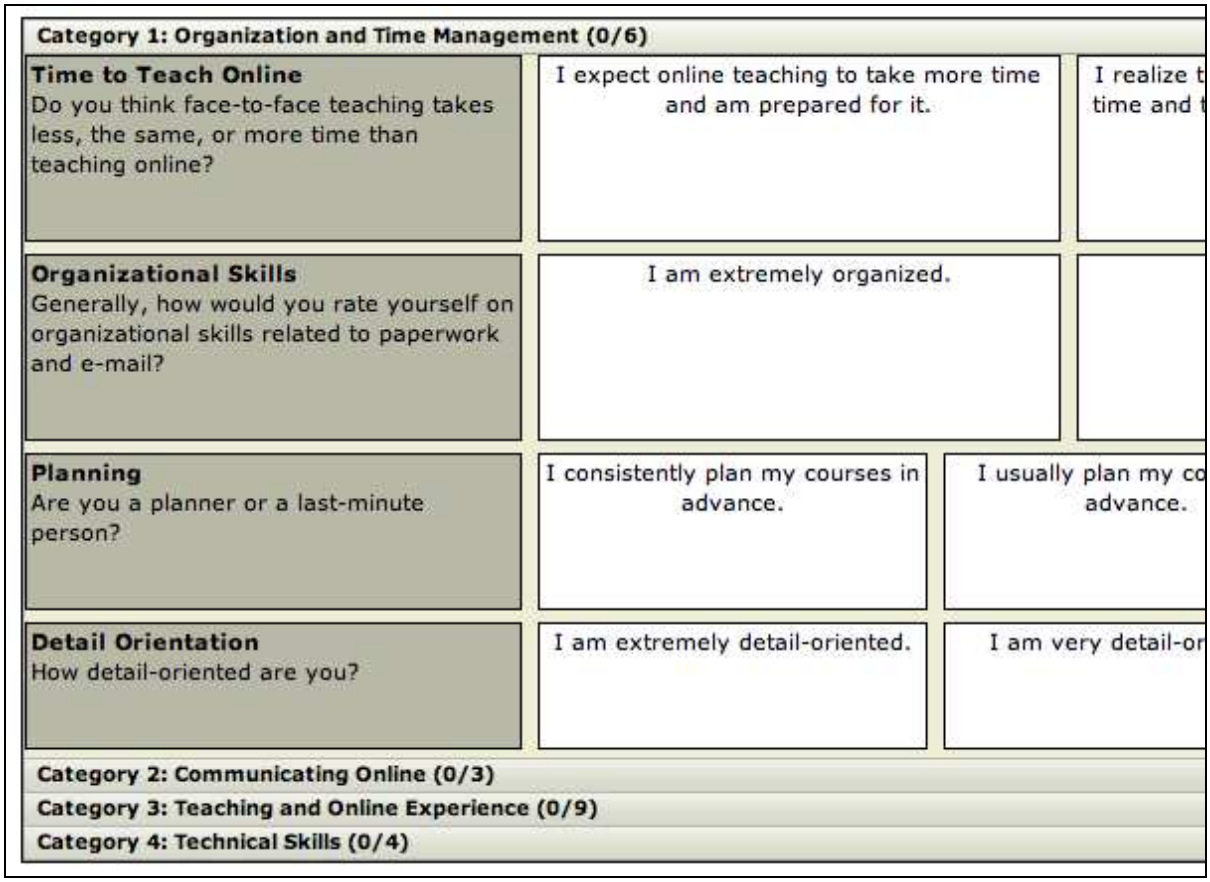

Figure 2: Categories as UI navigational elements

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