Probing the Landscape: Toward a Systematic Taxonomy of Online Peer Assessment Systems in Education

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ABSTRACT

We present the research framework for a taxonomy of online educational peer-assessment systems. This framework enables researchers in technology-supported peer assessment to understand the current landscape of technologies supporting student peer review and assessment, specifically, its affordances and constraints. The framework helps identify the major themes in existing and potential research and formulate an agenda for future studies. It also informs educators and system design practitioners about use cases and design options.

Keywords

Peer assessment, peer review, system design, rubric, scale

1. INTRODUCTION

In the twenty years that the web has been widely used in education, dozens, if not hundreds, of online peer assessment systems have appeared. They have been conceived by educators in many disciplines, such as English, Computer Science, and Design, to name a few. Topping [29] highlighted computer-aided peer assessment as an important pedagogical approach to developing higher level competencies. Surprisingly, most of these systems have been designed "from the ground up" — until now, there is little evidence that designers and developers of one system have consulted other systems to see what existing techniques are appropriate to their experience, and what can be done better. Several authors have conducted reviews of existing peer assessment approaches [4, 5, 8, 11, 19, 25, 28]. To the best of our knowledge, however, no one has proposed a systematic research framework for exploring and generalizing affordances and constraints of educational technology-enabled peer assessment systems.

Our Peerlogic project[1] is pursuing two primary goals: (1) to systematically explore the domain of technology-enabled peer assessment systems, and (2) to develop an arsenal of web services for a wide range of applications in such systems. We have examined a number of these systems, including such better known ones as Calibrated Peer Review [20], CritViz [26], CrowdGrader [6], Expertiza [9], Mobius SLIP [2], Peerceptiv [5] and peerScholar [14]. We adopt the term "*online peer assessment system*" to describe the broad range of computer applications purposefully designed and developed to support student peer review and assessment. Specifically, we define an online peer-assessment system as a web-based application that facilitates peer assessment process workflow, such as collecting submission artifacts, allocating reviewers to critique and/or evaluate designated artifacts submitted by peers, setting deadlines, and guiding reviewers on the format of the qualitative and quantitative feedback. This term covers a class of systems described in the literature as "computer (technology, IT, CIT, ICT, network, internet, web, cloud)-aided (assisted, based, enabled, mediated, supported)" peer assessment (review, evaluation) systems (in any combination). Online peer-assessment systems are a subset of a general class of social computing systems that involve peer review (including social networking and social-media applications, such as wikis, blogs, and discussion forums), but are distinguished by having specific workflow constraints and being directed at specific educational goals.

The purpose of this paper is to set up a framework for the systematic review and analysis of the current state of online peer assessment systems. We contrast our study with the earlier surveys by Luxton-Reilly [19] and Søndergaard and Mulder [25], which considered the facilities of individual systems one by one and then contrasted them. Our approach is to discuss functionalities of systems, and then describe how individual systems realize those funtionalities. Thus, in a sense, it is a dual of the earlier papers. Alternatively, one might say it applies the jigsaw technique [34] to them. Because of space limitations, this paper only begins to apply the taxonomy, which we will elaborate and extend in a future paper.

We use our framework to examine affordances and limitations of the systems that have been developed since 2005 and how they

[1] The Peerlogic project is funded by the National Science Foundation under grants 1432347, 1431856, 1432580, 1432690, and 1431975.

address pedagogical, philosophical, and technological decisions. We also exploit the framework to develop a research agenda to guide future studies. In this paper, we will begin to address these important research questions: *What is the current state of the online peer assessment in education? How is technology transforming and advancing student peer review?*

We address this study to several audiences such as peer assessment researchers, practitioners, system designers and educational technologists. Researchers in learning analytics can learn what peer-assessment data can be extracted and mined. Software designers can learn what has been designed and implemented in the past. Instructors applying peer review pedagogy in their classes can find what systems and functionality would best meet their needs. Instructors may turn to ed-tech specialists and instructional designers to answer these questions; thus, the latter also constitute an audience for this work. Conversely, marketers of these systems may identify the unique features of their systems so they can inform their constituencies.

2. FRAMEWORK AND METHODOLOGY

2.1 Framework

We applied a grounded theory approach to construct our framework. First, we identified all possible *use cases*, occurring in the online peer assessment. For this, we used an informal focus group, where faculty using peer assessment in their pedagogy described various situations and scenarios. In addition, academic papers on peer assessment were reviewed and relevant practices were brought to the discussion. Through this discussion of practices, the peer assessment process use cases were identified and categorized. Next, these use case categories were formalized as *objectives* of the peer assessment process. Thus, we obtained a classification of *system-independent* peer assessment objectives and respective use cases that support these objectives (Table 1).

Table 1. Primary objectives for online peer assessment systems

Objective	**Descriptive Questions**
I. Eliciting evaluation	How do student reviewers input evaluation data (quantitative and qualitative, structured and semi-structured)? What input controls are used to elicit responses?
II. Assessing achievement and generating learning analytics	How are peer assessment results computed and presented to instructors and to students? What assessment metrics can be used?
III. Structuring automated peer assessment workflow	What is the process of online peer review? What variations of this process exist?
IV. Reducing or controlling for evaluation biases	How assessment subjectivity can be reduced or controlled for? What metrics of assessment inaccuracy can be used?
V. Changing social atmosphere of the learning community	How online peer assessment can be conducted to achieve higher-level learning and other benefits?

These objectives and use cases are system-independent because they are not determined by the system in which they are realized but rather by the user needs independent of any system. In this paper, for illustration purposes, we focus only on objective I (Table 2).

Next, we examined a sample set of online peer assessment systems to identify how these use cases are implemented as functionality (features). In this study, we focus on functionality relevant specifically to the student peer-to-peer interactions in the review and assessment process and ignore complementary functionality that is germane to any learning, knowledge management or communication systems (such as learning-object content management). A given use case may be implemented in various systems as different ensembles of features, with varying design options. Therefore, functionality and design options are *system-dependent*. For each functionality, specific design options were identified and categorized.

Visually, our framework can be represented as hierarchically organized layers, where the top layer comprises objectives, which determine use cases, supported by functionality, implemented as specific design options (Figure 1).

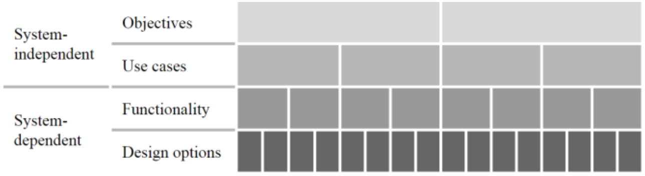


Figure 1. Research framework for a taxonomy of online peer assessment systems.

2.2 Data Collection and Analysis

Data collection was conducted through iterative paper presentation, system demonstrations, and discussions, documented as written notes and video recordings (including screencasts) shared online. Over three years, the authors have reviewed and experimented with multiple available systems, designed and implemented their own systems, systematically reviewed literature, and collaborated with other creators and users of systems in research and practice.

Identified, categorized and formalized themes, patterns, use cases, and design choices led to the construction of the framework. Then we used this framework to design questionnaires for surveys and structured interviews to collect additional data on each identified system. Collected data was synthesized in a spreadsheet, with formally defined “cases” and “variables”. Our current sample includes 40 systems described in the literature and found on the web. For the purpose of this paper, we illustrate our analysis with a subsample of selected systems (Figure 2). Finally, the multi-case method will be used to complete our taxonomy and to answer our research questions in the full study.

3. SAMPLE ANALYSIS

To demonstrate the application of our research framework for the analysis of the online peer assessment systems in education, in this paper, we focus on Objective I, “Eliciting evaluation”. We analyze the input mechanisms and controls that students use to conduct peer assessment. In general, the review process involves two tasks: (a) providing *quantitative* evaluations based on some criterion or criteria and using some scale, and (b) providing *qualitative* critiques or comments to peers' artifacts. Therefore, this objective is manifested in two distinct use cases: (I) "Eliciting quantitative peer evaluation" and (II) "Eliciting qualitative peer evaluation, critiquing and commenting". Use case I is supported by two functionalities: *rubrics* and *scales* used for quantitative assessment; use case II is also supported by two functionalities: *critique artifact media types* and *contextualization of critiques* (Table 2). We present below the taxonomy of specific design choices available for these functionalities and illustrate them with examples of specific systems.

Table 2. The application of the research framework for the analysis of objective I

System-independent		System-dependent	
Objective	**Use case**	**Functionality (features)**	**Design options**
I. Evaluation elicitation	Use case I: Eliciting quantitative peer evaluation	Rubrics	Holistic
			Specific / analytic
		Scales	Rating
			Ranking
	Use case II: Eliciting qualitative peer evaluation, critiques, comments	Critique artifact media types	Plain text
			Rich text / hypertext / URL
			Inline file annotation
			Multimedia attachments
		Contextualization of critiques	Non-contextualized
			Contextualized

3.1 Eliciting Quantitative Peer Evaluation

3.1.1 Rubrics

Rubrics are used at all levels of education to evaluate a wide variety of products. A rubric is an assessment tool that communicates expectations for an assignment submission. A well-designed rubric must consist of three essential components: *evaluation criteria*, *quality level definitions*, and a *scoring strategy* [20]. Evaluation criteria are the factors deemed to be important on which the goodness of the submission will be judged. Quality-level definitions specify achievement levels (e.g., "meets standards", "needs improvement") and help assessors understand what evidences those levels. The scoring strategy translates reviewer judgments into usable, often numeric, representations.

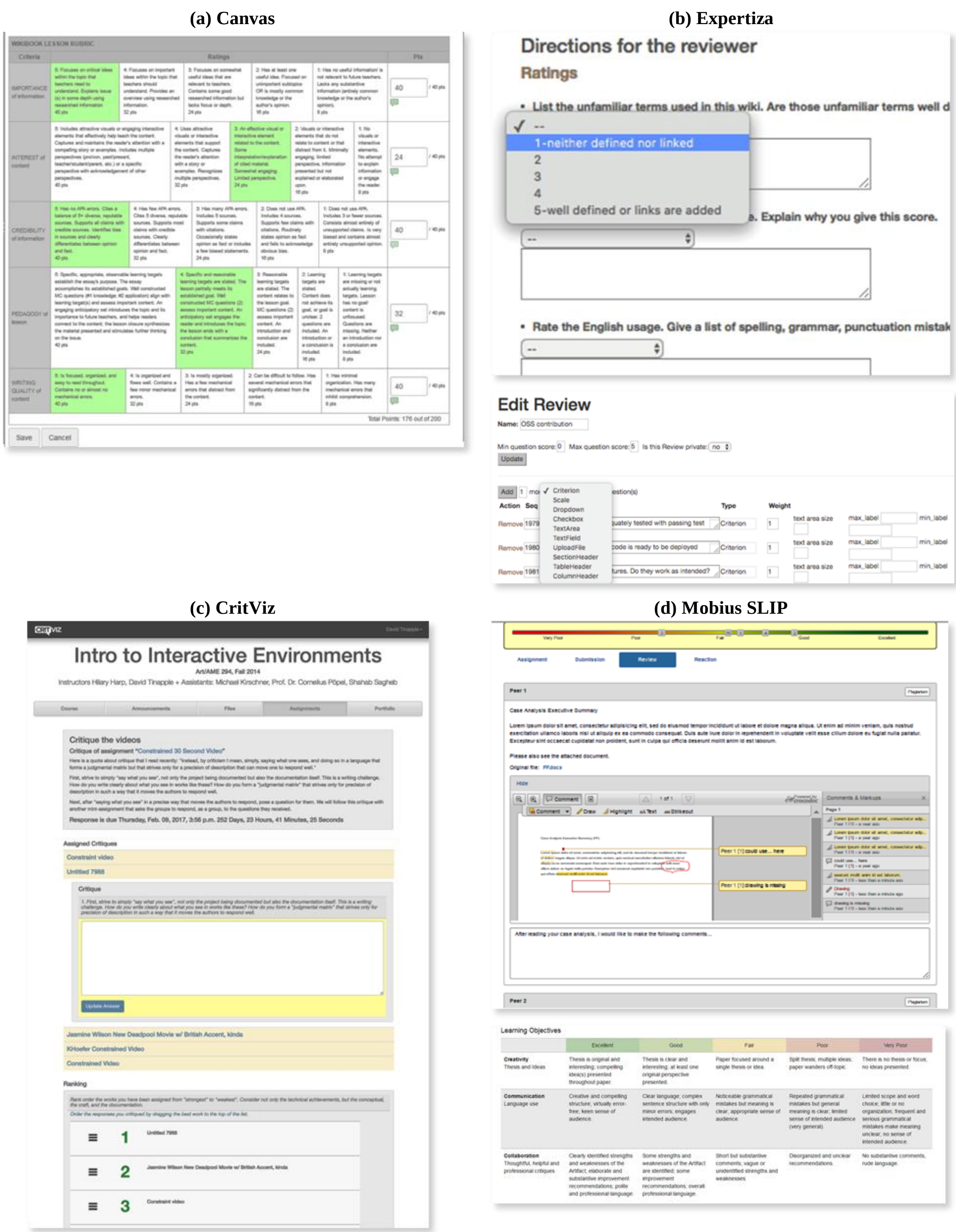
Rubrics can be categorized as *holistic* or *specific/analytical* [13, 15]. In a holistic rubric, a submission is judged as a whole, with a single value or category representing its overall quality. In contrast, a specific/analytic rubric requires evaluations on several distinct criteria.

In the context of peer review, we found that the term "rubric" has been used more loosely to describe a multitude of evaluative processes and structures. Some systems offer wide flexibility in design of rubrics that may or may not contain all three elements, while other systems are more restrictive. This leaves to the instructor assessment decisions, such as the type of rubric, the number of criteria, the number of achievement levels, the point value for each level, whether to use definitions, numeric scales, or both to delineate achievement levels. For example, in Canvas and Expertiza, a rubric can vary from a series of open-ended questions with no established quality levels or quantitative scores to an elaborate rubric with multiple criteria, detailed definitions, and a complex scoring strategy. In CritViz, a rubric is a set of questions that reviewers have to consider when evaluating peers' submissions. Mobius SLIP supports creation of a qualitative rubric complete with the essential components but elicits holistic quantitative evaluation (Figure 2).

Typically, online peer review systems, e.g., Expertiza, Calibrated Peer Review, Peerceptiv, and Canvas, support specific/analytical rubrics because they generate more detailed feedback that helps students understand their performance on each of these criteria. Specific rubrics provide a more granular picture of artifacts' strengths and weaknesses and more guidance to students as they complete subsequent revisions or assignments. Some systems, such as Mobius SLIP and CritViz favor holistic evaluations (even if some specific rubrics are provided); noticeably, these systems also rely in ranking (rather than rating) evaluations. Holistic rubrics make more sense for overall ranking, as it may be tedious for evaluators to rank multiple products on each of several criteria.

Limited choices in rubric design reduce the instructor's control over pedagogical implications of using different rubric types, but free them to focus on other aspects of instruction. Instructors new to assessment may appreciate not having to make too many of these decisions. Some systems fall in the middle, dictating some parameters, but allowing flexibility with others. For example, Peerceptiv allows instructors to determine the number of criteria, but requires each criterion to have a 7-point scale, unaccompanied by elaborated definitions. If rubric design is a critical factor in the institution's use of peer review process, instructors must carefully vet and select the system which best fits their assignment and assessment requirements.

In the context of peer review, rubrics are also associated with higher student achievement [18] and higher reliability of peer evaluations [12, 30]. Several studies suggested students need to engage with the rubrics in order for them to be effective [20]. Providing rubrics when an assignment is first given and asking students to complete self- and peer reviews were shown to be effective ways to facilitate this engagement.



(a) Canvas

WIKIBOOK LESSON RUBRIC

Criteria	Ratings					Pts
IMPORTANCE of information	5: Focuses on critical ideas within the topic that teachers need to understand. Explains issue (s) in some depth using researched information 40 pts	4: Focuses on important ideas within the topic that teachers should understand. Provides an overview using researched information. 32 pts	3: Focuses on somewhat useful ideas that are relevant to teachers. Contains some good researched information but lacks focus or depth. 24 pts	2: Has at least one useful idea. Focused on unimportant subtopics OR is mostly common knowledge or the author's opinion. 16 pts	1: Has no useful information/ is not relevant to future teachers. Lacks any substantive information (entirely common knowledge or the author's opinion). 8 pts	40 / 40 pts
INTEREST of content	5: Includes attractive visuals or engaging interactive elements that effectively help teach the content. Captures and maintains the reader's attention with a compelling story or examples. Includes multiple perspectives (pro/con, past/present, teacher/student/parent, etc.) or a specific perspective with acknowledgement of other perspectives. 40 pts	4: Uses attractive visuals or interactive elements that support the content. Captures the reader's attention with a story or examples. Recognizes multiple perspectives. 32 pts	3: An effective visual or interactive element related to the content. Some interpretation/explanation of cited material. Somewhat engaging. Limited perspective. 24 pts	2: Visuals or interactive elements that do not relate to content or that distract from it. Minimally engaging, limited perspective, information presented but not explained or elaborated upon. 16 pts	1: No visuals or interactive elements. No attempt to explain information or engage the reader. 8 pts	24 / 40 pts
CREDIBILITY of information	5: Has no APA errors. Cites a balance of 6+ diverse, reputable sources. Supports all claims with credible sources. Identifies bias in sources and clearly differentiates between opinion and fact. 40 pts	4: Has few APA errors. Cites 5 diverse, reputable sources. Supports most claims with credible sources. Clearly differentiates between opinion and fact. 32 pts	3: Has many APA errors. Includes 5 sources. Supports some claims with citations. Occasionally states opinion as fact or includes a few biased statements. 24 pts	2: Does not use APA. Includes 4 sources. Supports few claims with citations. Routinely states opinion as fact and fails to acknowledge obvious bias. 16 pts	1: Does not use APA. Includes 3 or fewer sources. Consists almost entirely of unsupported claims. Is very biased and contains almost entirely unsupported opinion. 8 pts	40 / 40 pts
PEDAGOGY of lesson	5: Specific, appropriate, observable learning targets establish the essay's purpose. The essay accomplishes its established goals. Well constructed MC questions (#1 knowledge; #2 application) align with learning target(s) and assess important content. An engaging anticipatory set introduces the topic and its importance to future teachers, and helps readers connect to the content; the lesson closure synthesizes the material presented and stimulates further thinking on the issue. 40 pts	4: Specific and reasonable learning targets are stated. The lesson partially meets its established goal. Well constructed MC questions (2) assess important content. An anticipatory set engages the reader and introduces the topic; the lesson ends with a conclusion that summarizes the content. 32 pts	3: Reasonable learning targets are stated. The content relates to the lesson goal. MC questions (2) assess important content. An introduction and conclusion are included. 24 pts	2: Learning targets are stated. Content does not achieve its goal, or goal is unclear. 2 questions are included. An introduction or a conclusion is included. 16 pts	1: Learning targets are missing or not actually learning targets. Lesson has no goal/ content is unfocused. Questions are missing. Neither an introduction nor a conclusion are included. 8 pts	32 / 40 pts
WRITING QUALITY of content	5: Is focused, organized, and easy to read throughout. Contains no or almost no mechanical errors. 40 pts	4: Is organized and flows well. Contains a few minor mechanical errors. 32 pts	3: Is mostly organized. Has a few mechanical errors that distract from the content. 24 pts	2: Can be difficult to follow. Has several mechanical errors that significantly distract from the content. 16 pts	1: Has minimal organization. Has many mechanical errors that inhibit comprehension. 8 pts	40 / 40 pts

Total Points: 176 out of 200

(b) Expertiza

Directions for the reviewer

Ratings

- List the unfamiliar terms used in this wiki. Are those unfamiliar terms well d

✓ --
1-neither defined nor linked
2
3
4
5-well defined or links are added

e. Explain why you give this score.

- Rate the English usage. Give a list of spelling, grammar, punctuation mistak

Edit Review

Name: OSS contribution

Min question score: 0 Max question score: 5 Is this Review private: no

1 mo estion(s)

Action	Seq		Type	Weight			
Remove	1979	uately tested with passing test	Criterion	1	text area size	max_label	min_label
Remove	1980	code is ready to be deployed	Criterion	1	text area size	max_label	min_label
Remove	1981	tures. Do they work as intended?	Criterion	1	text area size	max_label	min_label

(c) CritViz

Intro to Interactive Environments

Art/AME 294, Fall 2014

Instructors Hilary Harp, David Tinapple + Assistants: Michael Kirschner, Prof. Dr. Cornelius Pöpel, Shahab Sagheb

Critique the videos

Critique of assignment "Constrained 30 Second Video"

Here is a quote about critique that I read recently: "Instead, by criticism I mean, simply, saying what one sees, and doing so in a language that forms a judgmental matrix but that strives only for a precision of description that can move one to respond well."

First, strive to simply "say what you see", not only the project being documented but also the documentation itself. This is a writing challenge. How do you write clearly about what you see in works like these? How do you form a "judgmental matrix" that strives only for precision of description in such a way that it moves the authors to respond well.

Next, after "saying what you see" in a precise way that moves the authors to respond, pose a question for them. We will follow this critique with another mini-assignment that asks the groups to respond, as a group, to the questions they received.

Response is due Thursday, Feb. 09, 2017, 3:56 p.m. 252 Days, 23 Hours, 41 Minutes, 25 Seconds

Assigned Critiques

Constraint video

Untitled 7988

Critique

1. First, strive to simply "say what you see", not only the project being documented but also the documentation itself. This is a writing challenge. How do you write clearly about what you see in works like these? How do you form a "judgmental matrix" that strives only for precision of description in such a way that it moves the authors to respond well.

Jasmine Wilson New Deadpool Movie w/ British Accent, kinda

KHoefer Constrained Video

Constrained Video

Ranking

Rank order the works you have been assigned from "strongest" to "weakest". Consider not only the technical achievements, but the conceptual, the craft, and the documentation.

Order the responses you critiqued by dragging the best work to the top of the list.

≡ 1 Untitled 7988

≡ 2 Jasmine Wilson New Deadpool Movie w/ British Accent, kinda

≡ 3 Constraint video

(d) Mobius SLIP

Peer 1

Case Analysis Executive Summary

Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

Please also see the attached document.

Original file: FF.docx

After reading your case analysis, I would like to make the following comments...

Peer 2

Learning Objectives

	Excellent	Good	Fair	Poor	Very Poor
Creativity Thesis and Ideas	Thesis is original and interesting; compelling idea(s) presented throughout paper.	Thesis is clear and interesting; at least one original perspective presented.	Paper focused around a single thesis or idea.	Split thesis; multiple ideas; paper wanders off-topic.	There is no thesis or focus; no ideas presented.
Communication Language use	Creative and compelling structure; virtually error-free; keen sense of audience.	Clear language; complex sentence structure with only minor errors; engages intended audience.	Noticeable grammatical mistakes but meaning is clear; appropriate sense of audience.	Repeated grammatical mistakes but general meaning is clear; limited sense of intended audience (very general).	Limited scope and word choice; little or no organization; frequent and serious grammatical mistakes make meaning unclear; no sense of intended audience.
Collaboration Thoughtful, helpful and professional critiques	Clearly identified strengths and weaknesses of the Artifact; elaborate and substantive improvement recommendations; polite and professional language.	Some strengths and weaknesses of the Artifact are identified; some improvement recommendations; overall professional language.	Short but substantive comments; vague or unidentified strengths and weaknesses.	Disorganized and unclear recommendations.	No substantive comments; rude language.

Figure 2. Screenshot of selected online peer assessment systems

While rubrics are typically viewed as an assessment tool, many researchers suggested that they have a second, often overlooked, instructional purpose. When used formatively, rubrics can illuminate strengths and weaknesses and suggest a direction for future improvements. Rubrics help students understand what to change in their work and help educators see where future instruction should be directed. Interestingly, studies of student perceptions of rubrics suggested that students value these formative purposes. Students observed that rubrics clarify the objectives for their work, help them plan their approach, check their work, and reflect on feedback from others. They also report producing better submissions, earning higher grades, and feeling less anxious about assignments when they are provided with a rubric [20].

Empirical studies support students' impressions, providing evidence that rubrics support teaching and learning and contribute to higher achievement [13, 20].

Online peer review systems offer a variety of means for supporting the formative use of rubrics. Some allow different rubrics to be used for different rounds of peer review within a single assignment; others offer calibration to show students how peer evaluations compare to the instructor assessment on a selected sample assignment. Many systems allow student achievement scores to be calculated in different ways depending on whether peer review is used for formative or summative purposes. These features, while important to this discussion, are beyond the purview of this paper, and will be discussed in a future publication.

3.1.2 Scales

In general, quantitative evaluations may be conducted using either *ranking* or *rating* [9]. Rating refers to the comparison of different items using a common *absolute*, or *cardinal*, scale (either numeric or categorical). Ranking, sometimes also called forced-distribution rating, means comparing different items directly one to another on a *relative*, or *ordinal*, scale [22]. Both ranking and rating have their strengths and weaknesses, and there is still little consensus as to which has a greater predictive validity [1, 16, 17].

Generally, ranking and rating are expected to correlate, but some studies have demonstrated that ordinal (ranking-based) evaluations contain significantly less noise than cardinal (rating-based) evaluations [23, 32]. A cardinal scale in the context of peer evaluations is also susceptible to score inflation, whereas an ordinal scale is immune to this problem [9]. When a cardinal scale is used, an evaluator may "smokescreen" his preferences by giving all evaluated artifacts the same rating, and may severely inflate scores by giving all artifacts the same high ratings (similarly, he can severely degrade scores by giving all artifacts the same low ratings). Thus, a cardinal scale is very vulnerable to social or personal biases (e.g., "never give the highest rating") and idiosyncratic shocks (e.g, mood or inconsistency in evaluation style). When an ordinal scale is used, an evaluator must construct an explicit total ordering of artifacts (based on their perceived quality) over others [24]. This makes the evaluation more robust. Psychological evidence suggests that evaluators are better at making comparative judgments than absolute ones [26, 31].

The ordinal scale also has its drawbacks. It forces evaluators to discriminate between artifacts that may be perceived to have very similar quality as much as between the artifacts whose qualities may be far apart. Some ordinal scales may implicitly emphasize items earlier in the list and lead to their higher ranking. Evaluating on ordinal scales places higher cognitive load on the evaluators because it requires them to compare multiple items against each other. Thus, rubrics that use ordinal scales tend to contain fewer criteria, and consequently, they may not draw evaluators' attention to as many salient features of the artifact under review. Scores from rating-based systems are usually determined by calculating a weighted average of scores given to various criteria, which means they depend on multiple, independent decisions by each evaluator, rather than a single decision of how to rank this submission relative to others.

Most online peer assessment systems are rating-based, e.g., Calibrated Peer Review, Peerceptiv, Expertiza. Typically, a rating scale is presented as a drop-down menu or validated text box. Ranking-based systems have been also gaining prominence thanks to the strengths of the ordinal evaluation approach. In CritViz, for example, students have to "drag and drop" submission artifacts to position them in the ranking order according to the reviewers perception of their quality. Yet other systems attempt to take advantage of combining both evaluation scales in a single control. For example, in Mobius SLIP, the SLIP Slider control (figure 2) allows recording ratings on the 0-100 scale as well as ranking, which then can be used separately to generate analytics and grading data. Naturally, for such controls to function, they should exclude the possibility of assigning the same rating to any two artifacts, but they allow placing two artifacts close to each other to indicate approximately the same level of quality. Another example of a system that supports both ranking and rating scales is peerScholar [14], where the instructor can configure an assignment to have either a rating scale or a ranking scale. Inasmuch as long rubrics also seem to elicit more textual feedback, systems that use ranking may provide the author with less feedback on the quality of the submission and guidance how to improve it [35].

3.2 Eliciting Qualitative Peer Evaluation

3.2.1 Critique Artifact Media Types

Critiques, as the verbal component of reviews, can be provided in different formats. The most obvious and typical design choice is to prompt the reviewer to post a *plain-text* comment in a text box. Most systems provide a web form combining rubric questions and text boxes to fill out. Plain-text feedback is the most basic and arguably the fastest way to provide feedback. Textual critiques can be enhanced by allowing *rich-text* format (varying font faces and sizes, bullet points, alignment, hyperlinks, etc.) using the WYSIWIG editors. Including a *hyperlink* in the text feedback further enhances the options by referencing an externally hosted copy of the submission artifact (which can be edited and/or annotated) or by referencing externally hosted multimedia critique artifacts, such as voice and video recordings, screencasts and HTML documents. Only a few systems (e.g, Canvas) allow internal hosting of multimedia critique artifacts, but arguments have been made that this type of critiques substantially improves the provider's efficiency and the recipient's experience.

The next step up in providing rich critiques is *inline file annotation*. Several systems take advantage of the third party APIs allowing inline file annotations of submission artifacts uploaded as files. For instance, Mobius SLIP and Canvas utilize a document viewer called Crocodoc, which renders various file formats as an HTML document and allows reviewers to select portions of the document and annotate them in place. Annotation includes highlighting, commenting, adding text and primitive graphic elements. This feature is similar to adding comments in a Microsoft Word file or a Google doc. Crocodoc supports both non-anonymous and anonymous file annotation. While the Crocodoc API is used by a number of systems, after its acquisition by Box in 2013, it is expected to be replaced by a new API with similar, and possibly, more advanced inline file annotation functionality. *Web annotation* is another possible implementation of inline annotation in the web-based online peer assessment systems [33] but no systems in our illustrative sample rely on it; therefore, this option needs to be explored further. To the best of our knowledge, no existing online peer review systems offer its "native," custom-built inline file annotation functionality.

Since text critiques may not offer the desired expressiveness and clarity that other media may provide, users have been requesting to allow reviewers to *attach multimedia files* containing critique artifacts (e.g., images, voice or video recordings) as an alternative to inserting URLs to such externally hosted files in the plain- or rich-text comments. Such an option, for example, would allow reviewers, who are more comfortable using traditional media (e.g., pen and paper), to write their critiques offline, then scan them into pdf or image files, and then attach them to the original submission artifacts. For another example, some reviewers may also be more productive when providing their critiques as voice or screencast recordings made directly in the system. In our sample only Canvas offers such options, but since they are available in other social learning applications, such as VoiceThread (voicethread.com), it is reasonable to expect increasing availability of such functionality in online peer assessment in the near future.

3.2.2 Contextualization of Critiques

A number of factors influence how well the author of the submission artifact is able to understand and relate to a reviewer's feedback: spatial relationship of the critique artifacts with the submission artifact, placing critiques in the specific context of the submission artifact, and the granularity of comments. For example, directly annotating an issue in a fragment of the submission artifact, rather than trying to explain in the overall, "detached", critique where the issue is located and how to fix it, simplifies communication between the reviewer and the author. Moreover, annotation is more suitable for providing specific fine-grained comments, while filling out a text box is more appropriate for more global comments.

We define this aspect of eliciting qualitative evaluation as the *contextualization of critiques*. Naturally, the system interface design determines how much critiques can be contextualized in relation to submission artifacts. Moreover, the interface implementation of other functionalities, such as rubrics, scales and critique artifact media types closely interplays with the implementation of critique contextualization. Contextualization of critiques, thus, has two options: (a) "detached", non-contextualized ("single comment per submission"); (b) contextualized ("multiple comments in various fragments of the submission"). While the former is typically available in all systems in our sample, the latter is implemented as either an entry space (textbox) associated with a specific criterion/question in the rubric (e.g, Expertiza, CritViz) or as inline file annotation with Crocodoc (e.g., Mobius SLIP, Canvas). Further exploration of this functionality and design options for its implementation will be provided in the full study.

4. CONCLUSION

We have presented our initial attempt at formulating the research framework for a taxonomy of educational online peer assessment systems. This framework enables researchers of technology-supported peer assessment to understand the current landscape of technologies supporting student peer review and assessment, specifically, its affordances and constraints. Importantly, this framework helps identify the major research questions in existing and potential research and formulate agenda for the future studies. It also informs educators and system design practitioners about use cases and design options in this particular branch of educational technology.

Using a grounded theory approach, we identified several primary objectives for online peer assessment systems and combined them in the research framework. To illustrate the application of this framework in this research-in-progress paper, we presented a sample analysis of how use cases supporting the objective of eliciting quantitative and qualitative peer evaluations are implemented in several different systems. In the future, full study, we intend to apply the multi-case method to conduct a complete analysis of the objectives based on a large sample of online peer assessment systems.

5. REFERENCES

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