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Introduction

There is a growing movement within the engineering education community towards incorporating real-world design experiences into the curriculum, where teams of students work with or for a client to solve a problem. In these circumstances, clients are generally aware that they are working with students instead of professionals, and so are more willing to provide formative feedback to critique student efforts. One way of easily providing such feedback is through the use of rubrics; unfortunately, a literature search failed to turn up any rubrics designed specifically for student-client interactions within engineering. Accordingly, the development of a "Client Interaction Rubric" as discussed here fulfills this identified need while serving two purposes: obtaining formative feedback from the clients to help improve students' client interaction skills, and providing students ahead of time with a framework of key criteria regarding having successful interactions with clients.

This paper describes initial efforts to develop a rubric in support of student-client interactions for client-oriented project-based learning activities. The rubric has been tested in two small, private college environments: a user interface design course at Ohio Northern University taken by both computer engineering and computer science majors, and an engineering capstone design course at Smith College in Massachusetts. The goal of this research is to develop and disseminate a versatile rubric that can be used for formative assessment in a variety of settings involving student-client interactions.

Motivation and Prior Work

The research presented here was initially motivated by continuing efforts at Ohio Northern University (ONU) to instill an "entrepreneurial mindset" in its engineering students. Colleges in the Kern Entrepreneurial Engineering Network (KEEN) are both developing and promoting a new educational paradigm that not only includes instruction in the technical fundamentals of engineers but also incorporates an introduction to business principles, insight into the importance of customer awareness, and a focus on societal needs and values.[1] According to the KEEN Framework,[2] individuals who have an entrepreneurial mindset demonstrate curiosity, make connections across various sources in order to gain new insights, and create value by persisting through failure.[3] Such skills are not so much learned as they are cultivated through providing multiple opportunities to apply the related mindset practices throughout the curriculum. Previous efforts have resulted in successfully incorporating such activities into the term project for a second semester introductory programming course, where student teams develop educational software for real-world clients.[4] To assist and guide the students in this effort, rubrics were utilized as the primary means for performing formative assessment throughout the project. It was through this prior work that the Single-Point Rubric format was encountered and adopted for use.[5] Based on the positive results of using such rubrics, other term projects within the ONU computing curricula were evaluated for their potential to be augmented by such an assessment tool.

Rubrics: Overview

The term "rubric" refers to a guide used to evaluate the quality of constructed responses or behaviors that contains three essential features: evaluative criteria, quality definitions, and a scoring strategy.[6,7] Evaluation criteria are the factors considered when determining the quality of work, quality definitions provide a detailed explanation of what must be demonstrated to attain a particular level of achievement, and scoring strategies involve the use of a scale for interpreting judgments of a product or process.[8] Holistic scoring strategies require the user to take all of the evaluative criteria into account as part of a single overall quality judgment, whereas analytic scoring strategies allow the user to make a series of judgments for each evaluative criterion present.[9]

While rubrics have been commonly used summatively to grade student work, the use of rubrics as part of an ongoing process of formative assessment has been gaining attention because they provide students with appropriate guidance prior to an activity.[7] Amongst the benefits of this approach are the potential for improved student performance through taking greater responsibility for their own learning, increasing transparency and reducing anxiety by communicating clear and specific expectations to the students, and improving self-efficacy through timely instructor feedback that provides opportunities to revise products and deepen understandings.[10,11] Due to the evaluation of each individual criterion, the analytic rubric (*i.e.*, a rubric employing an analytic scoring strategy) can be effectively used in formative assessment applications. Figure 1 shows one example criterion from an analytic rubric for scoring the task of serving breakfast in bed.

Breakfast in Bed				
	Excelled **3 Stars**	**Mastered** **2 Stars**	**Developing** **1 Star**	**Beginning** **0 Stars**
Food	Perfectly cooked and seasoned to preference.	At correct temp, seasoned ok,	Some food too hot or cold, or is under- or over-seasoned.	Most food too hot or cold and is under- or over-seasoned.

FIGURE 1. EXAMPLE ANALYTIC RUBRIC CRITERION (IN ESTELL[4], ADAPTED FROM GONZALEZ[12])

Regardless of the methodology[13,14] selected for rubric development, analytic rubrics present inherent challenges that must be taken into consideration.[15] First, an analytic rubric must be designed for consistency in the performance criteria descriptors across all scale levels, a task that can be both challenging and time-consuming. Reliability can be an issue if generic terms – such as "highly", "some", "moderately", and "minimal" – are the only differentiators used in the scale levels of a particular performance criterion. The desire to cover all possible modes of failure within a set of performance criteria descriptors can take a considerable amount of time to accomplish. The inclusion of negative terminology, in turn, can incorporate a tone of failure that might deter struggling students. Incorporating too much resolution in a set of performance descriptors may adversely impact the time needed to score a particular criterion. Another challenging aspect of analytic rubrics is that they generally have limited blocks of white space, leaving little (if any) room for providing written feedback. Finally, students have to read and understand the contents of the rubric but, given the dense and somewhat repetitive nature of the information, may gloss over essential differentiating elements for a criterion.

Rubrics: The Single-Point Rubric

Single-point rubrics[12,16,17] offer an alternative to traditional analytic rubrics. As stated by Fluckiger,[18] one of the purposes of the single-point rubric is "to provide specific written feedback on various aspects of students' work that will help them know *how* to improve." (p. 20) An example of a single-point rubric criterion for the aforementioned serving breakfast in bed scenario is shown in Figure 2.

Breakfast in Bed		
Advanced Evidence of exceeding standards	**Criteria** Standards for this performance	**Concerns** Areas that need work
	Food: All food is at the correct temperature, adequately seasoned, and cooked to the recipient's preference.	

FIGURE 2. EXAMPLE SINGLE-POINT RUBRIC CRITERION (IN ESTELL[4], ADAPTED FROM GONZALEZ[12])

While similar to an analytic rubric, the key distinguishing characteristic of the single-point rubric is that, for each criterion, only the expected level of performance is provided with a qualitative definition or precise quantitative measure. The remaining performance levels are deliberately left unspecified. The single-point rubric thereby presents a single set of criteria, or one point, for students to consider. This approach solves many of the problems inherent with the analytic rubric.[17,18] First, students can clearly see what the instructor's expectations are, as now only the standards for proficiency are present. This simplifies matters greatly, as the various performance levels specified in an analytic rubric's criterion can be overly detailed or nuanced, often to the point of confusion. By providing just a single point per criterion, students can now focus on a clear, well-defined set of "success criteria" without any additional distractions. Second, less development time is required in constructing the single-point rubric, as the focus is now solely on success. Determining all the ways that a student can do things wrong is very time-consuming for the instructor and can result in a document whose overall complexity makes it difficult for students to discern the actual performance expectations. Additionally, it is unlikely that an instructor can capture all possible failure modes within a rubric, so when such a trait is encountered, additional time must be spent determining where that trait falls within the performance criterion levels. Third, the single-point rubric does not provide an upper bound via a list of exemplary traits. By explicitly providing such traits as the highest performance level in an analytic rubric, instructors unwittingly create a target for overachievers, who now have no incentive to go "off script" in terms of creativity for fear of not getting the maximum number of points possible. By removing these traits, one no longer constrains student potential to only that which is specified – the rubric is now open-ended, thereby encouraging creativity. Finally, the open spaces on either side of the center column provide room for writing targeted, specific comments of praise and/or encouragement regarding that student's work, thereby providing an avenue for formative assessment. In contrast, the typical analytic rubric provides feedback primarily through the circling of blocks of text that best match reviewer observations. This approach lacks the personalization that direct feedback can provide in helping to meet an individual student's learning needs.

Initial Development of the Client Interaction Rubric

The initial criteria for the Client Interaction Rubric were extracted from relevant KEEN Student Outcomes (KSOs) developed at Ohio Northern University[19], in particular, elements of Outcome 1 (curiosity) and Outcome 4 (communication), as noted in Table 1.

TABLE 1. SET OF RELEVANT ONU KSO MEASURES

KSO	Description of Measures
1a	Develop a propensity to ask MORE questions.
1b	Be able to formulate SALIENT questions.
1c	Question information that is given without sufficient justification.
1e	Recognize and explore knowledge gaps.
1f	View problems with an open mindset and explore opportunities with passion.
4c	Provide and accept constructive criticism, including self-evaluation.
4f	Manage informal communications.

The single-point rubric format was explicitly chosen for its abilities to clearly state performance expectations and solicit qualitative feedback. The rubric layout was divided into a set of categories that roughly follow the timeline of a typical client interaction: preparatory activities, status reporting, planned questions, and follow-up questions. Two additional categories, mindset and professionalism, were also included to capture traits that should be present throughout the interaction. For each category, multiple measures were developed and mapped where possible to the ONU KSOs as indicated in Figure 3. The items denoted within parentheses map to the indicated rows in Table 1.

Above and Beyond	Meets Expectations	Needs Improvement
	Preparatory Activities: • Meeting scheduled in advance (4f) • Agenda provided ahead of time (4f) • Agenda indicates scope of meeting (4f)	
	Status Reporting: • Covers what was accomplished • Indicates problems delaying progress (4c) • Outlines next steps	
	Planned Questions: • Focuses attention on the key issues (1b) • Have a thoughtful quality to them (1b)	
	Follow-up Questions: • Willingness to ask additional questions based on responses (1a) • Focuses on understanding the rationale behind initial responses (1c) • Shows attempt to discern true needs of the client (1a)	
	Mindset: • Views situations with an open mind (1f) • Willingness to explore opportunities (1f)	
	Professionalism: • Respects time-based meeting constraints (starting time, duration, *etc.*) (4f) • Uses appropriate language recognizing knowledge gaps between the parties (1e)	

FIGURE 3. VERSION 1 OF CLIENT INTERACTION RUBRIC

Initial Testing and Feedback

The Client Interaction Rubric was used and tested during the Fall 2016 semester in two environments: a user interface design course taken by both computer engineering and computer science majors at Ohio Northern University, and an engineering capstone design course at Smith College.

The user interface design students were divided into two groups; each was tasked with a term project involving a client that required multiple interactions and the delivery of recommendations in a final report. The first group worked with a web developer client from the ONU Communications and Marketing Department to work on the university web site's calendar software. The second group had as its client the administrator of CDHub 2.0 Capstone Design Hub (CDHub), a website designed to provide a rich, interactive repository for the engineering capstone design community.[20] (This client is one of the co-authors of this paper.) In order to provide experience with Skype-based communications, both groups were involved with the initial online meeting with the CDHub administrator. The instructor provided the Client Interaction Rubric to the students and reviewed it with them before this online meeting. The rubric was also provided to the CDHub administrator client for review after the meeting.

The initial version of the rubric was also given to two capstone design teams at Smith College after their kick-off client meeting to use as a framework to debrief and assess their performance in the meeting. The course instructor facilitated the rubric discussion separately with each team, making notes on the rubric based on student feedback. One of the teams asked to keep the annotated rubric for reference in planning for subsequent client meetings.

Informed by this initial implementation in different settings, the authors made some modifications to the rubric, in particular, adding two new performance categories and several additional measures to the existing categories. The user interface design students were presented with the feedback from their client meeting along with the second version of the rubric. Each student was asked to write a reflective mini-essay regarding what could be done to improve performance for the next client meeting, and to provide feedback regarding the new version of the rubric. Collectively, the reflective pieces indicated a need for a more informative agenda and delegating team members' roles with respect to the meeting. The students indicated that the revisions to the rubric were very clear, but also made some suggestions for further improvement that informed subsequent rubric versions.

Rubric Reliability, Validation, and Refinement

Given the positive feedback received from the initial use of the Client Interaction Rubric, the authors implemented a systematic review and refinement of the instrument, including examining it for reliability and subjecting it to validation. The overall goal was to arrive at a streamlined rubric that aligned well with constituent needs.

Reliability
The reliability of an assessment instrument involves assuring scoring consistency in its use. While there are several factors that play a role, two factors – inter-rater reliability and clarity – are of particular interest to this work. Inter-rater reliability refers to the concern that a score for a

particular artifact under consideration may vary from rater to rater. Consequently, formalizing the set of performance descriptor levels for each measure is critical in reducing the occurrence of discrepancies.[21] This task is substantially easier for a single-point rubric than for an analytic rubric because only one performance level per criterion contains a description. Clarity refers to the concern that the measures are both explicit and easy to understand by all parties. The first step to establish clarity, which was performed earlier by the students, is by a check for understanding: the rubric is reviewed with respect to whether the criteria are sufficiently defined so that everyone understands what constitutes expected performance and that the differences between categories are clear.[21] Again, the single-point rubric benefits from its simplicity, as language for only the expected performance standard needs to be crafted.

Validation

A generic definition of validation involves asking the question, "Are we building the right system?"[22] It is the extent to which stakeholders can justify the appropriateness of using an assessment instrument for a specific purpose.[23] Validity is not a property of an assessment instrument, but a function of how that instrument is used and interpreted. Accordingly, due to the wide diversity of possible settings of the educational variables involved, evaluating the appropriateness of an instrument's use is an ongoing process.

To obtain evidence regarding the validity of the Client Interaction Rubric, the authors decided to solicit the input of a key group of stakeholders: members of the Ohio Northern University College of Engineering Industrial Advisory Board. During their Fall 2016 meeting, the 10 attending members were asked to separately address the following task: "List those criteria that you commonly use to determine whether or not you have had a positive meeting experience either *as* a client or *with* a client." In order to avoid any potential bias, the advisory board members were not provided with a copy of the Client Interaction Rubric. The 66 comments received were entered into a spreadsheet to allow for ease of classification into one of three categories: already present within the rubric, possible revisions to the rubric, and not applicable to the client interaction task. Overall, the comments validated much of the existing rubric and informed some modifications. Some comments also pointed out the need for a second instrument dedicated to preparations for and execution of the initial meeting with the client.

Informed by the validation exercise, the authors determined that the rubric should include the following eight performance objectives, and they updated the rubric accordingly:

- Prepares in advance for the meeting
- Appraises the current project status
- Develops and asks eliciting questions
- Generates and asks appropriate responsive questions
- Confirms results before concluding the meeting
- Summarizes results in writing
- Employs a mindset that prioritizes listening
- Demonstrates professional conduct

Formatting Refinement

In parallel with the Advisory Board validation activities, the third version of the rubric was tested with the user interface design class and the CDHub administrator client in conjunction with one of their scheduled monthly meetings. The consequent filling out of the rubric by the client exposed a critical weakness inherent to the single-point rubric: an inability to provide qualitative comments for performance that is rated as meeting expectations.

Addressing this shortcoming was the primary motivation for the development of the fourth version of the Client Interaction Rubric, a full copy of which is provided in the Appendix. For comparative purposes, Figure 4a shows a snippet from the first version of the Client Interaction Rubric, employing the traditional single-point rubric format, while Figure 4b illustrates the revised format using a snippet from the current rubric.

Above and Beyond	Meets Expectations	Needs Improvement
	Preparatory Activities: • Meeting scheduled in advance (4f) • Agenda provided ahead of time (4f) • Agenda indicates scope of meeting (4f)	

FIGURE 4A. SNIPPET FROM VERSION 1 OF CLIENT INTERACTION RUBRIC, USING TRADITIONAL FORMAT

	Rating Check one per row, or strikethrough all if not relevant			Comments Provide comments for each evaluation section, especially for performance marked above or below expectations
	Above	Meets Expectations	Below	
Preparation	☐	☐ Scheduled meeting in advance	☐	
	☐	☐ Sent or requested materials in advance	☐	
	☐	☐ Provided agenda ahead of time	☐	
	☐	☐ Identified scope of meeting	☐	
	☐	☐ Identified active participants	☐	

FIGURE 4B. SNIPPET FROM VERSION 4 OF CLIENT INTERACTION RUBRIC, USING REVISED FORMAT

The essence of the single-point rubric is maintained by having only one quality definition per performance objective, but now the spaces previously reserved for commenting on performance that is either above or below expectations has been replaced by columns just wide enough to contain a checkbox for indicating which performance level has been observed. The rightmost column of the revised rubric is now used as a qualitative response area common to all performance level observations. The "Comments" field is oriented towards soliciting responses for each performance objective to allow for the option of providing feedback that is either specific to a measure or general to the objective.

The Current Client Interaction Rubric

The current Client Interaction Rubric (presented in the Appendix) includes eight sections related to performance before, during, and after a meeting, as well as professionalism throughout. Details on the components of and justification for these sections, mapped to the associated Performance Objectives (PO), are described below:

- Before (PO-1): The single section on *Preparation* addresses expectations associated with scheduling and scoping the meeting, providing materials in advance, and identifying the appropriate meeting participants.
- During (PO-2 through PO-5): The section on *Status* covers the discussion of accomplishments, issues, and next steps. The two sections on *Planned Questions* and *Responsive Questions* address expectations regarding the preparation and delivery of questions planned in advance, as well as those developed and asked in response to client discussion in the meeting itself. The *Conclusion* section focuses on effectively concluding the meeting, including goals, decisions, next steps, and evaluation.
- After (PO-6): The single section on *Follow-Up* covers expectations related to communications conducted between the students and client after the meeting has ended.
- Overall (PO-7 and PO-8): The two sections on *Mindset* and *Conduct* address aspects of professional behavior and interaction, including respect, listening, open-mindedness, reaction to change, timeliness, language, and participation.

Reflections

Following revision and implementation of the current Client Interaction Rubric, the authors solicited feedback from the students at both ONU and Smith. Discussion of this feedback, and comments from the CDHub administrator client (and co-author) are presented below.

Student Reflection
A brief survey with three open-response questions was administered to students at ONU following the completion of the user interface design course and to students at Smith at the mid-point of their two-semester capstone design course. For the question, "What do you think the intent was of the Client Interaction Rubric?" the responses focused on three aspects. First, to help the students properly prepare for their client interactions. Second, to provide structure so that the meeting could be effective. Finally, as a means for evaluating student performance. For the question, "What did you like most about the Client Interaction Rubric?" students noted that the rubric was "*surprisingly useful when preparing for meetings.*" It was also clear in that it "*told us exactly what we needed to have done*" and "*gave the team a sense of direction toward what we should be expecting.*" One student appreciated that "*the rubric wasn't a number-based rubric*" which therefore "*allowed for the person filling it out to provide more substantial feedback.*" Another student appreciated the presence of the Mindset category "*as a reminder of those additional important components that aren't vital but just as important to having a productive meeting.*" When asked, "What changes would you recommend to make a Client Interaction Rubric more useful?", there were no suggestions; instead, the students provided responses such as "*the most recent rubric was fine as is,*" "*I can't think of anything,*" and "*it is great as is.*" One Smith student noted that it would have been nice to use the rubric more frequently.

The ONU user interface design students were also asked to view their term project as a whole and reflect upon what they would take away from the experience and apply to their future classes and career. In their responses, students noted that the course gave a "*unique view on how client interactions work*" as "*working with an actual client was something that I had never done prior to our project.*" Two major themes emerged: that proper design implementation requires "*an enhanced understanding of the user base*," and that meeting preparation is an essential component of the "*working with a client experience*" that benefits both the student and the client. Finally, it is worth noting that one student, unsolicited, mentioned that "*I plan to use the client interaction rubric to ensure that my team and I carry ourselves in a proper/professional manner while working with our clients*."

Client Reflection
From the client perspective, the Client Interaction Rubric served as a formal structure to document student performance related to meetings and then discuss this performance with the course instructor. The ability to identify what the students did well and where they could improve was especially useful. The initial versions of the rubric did not provide sufficient space for comments, but that was remedied in the current version. While the rubric provided value for debriefing performance after meetings, its primary value is in preparation for meetings, because it spells out clearly what actions and outcomes are expected in a meeting. When the students reviewed the rubric in advance of a client meeting they seemed better prepared and the meeting was more effective.

Conclusions and Future Directions

The goal of this research was to develop and disseminate a rubric to enable formative assessment of student-client interactions in client-oriented project-based learning activities. Through its use with both students and clients, plus input and validation from an Industrial Advisory Board, the Client Interaction Rubric has undergone multiple refining iterations. The current version of the rubric offers the pedagogical and logistical benefits of a single-point rubric as well as the means for recording qualitative feedback regardless of the cited performance level. The rubric includes components to support students before, during, and after a client interaction, as well as for demonstrating their professionalism throughout the process. The rubric has received positive reviews by students at two institutions who used it to help guide their interactions with real-world clients. The authors now invite the greater engineering education community to apply this rubric in their own academic settings to help support their students' interactions with clients.

Acknowledgement

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Appendix: Client Interaction Rubric version 4.4b

The Appendix on the next page contains version 4.4b of the Client Interaction Rubric, which was the current version of the rubric at the time of paper submission. Readers who would like the latest version of the Client Interaction Rubric in Microsoft Word format are encouraged to contact the authors directly to request an electronic copy. Requestors may be asked to provide feedback to assist with the further development and refinement of this and similar rubrics, such as the initial meeting preparation rubric.

Client Interaction Rubric

Team/Project: _____ **Date:** _____

Performance Objectives		Above	Meets Expectations		Below	Comments — Provide comments for each evaluation section, especially for performance marked above or below expectations
		Rating — Check one per row, or strikethrough all if not relevant				
	Preparation	☐	☐	Scheduled meeting in advance	☐	
		☐	☐	Sent or requested materials in advance	☐	
		☐	☐	Provided agenda ahead of time	☐	
		☐	☐	Identified scope of meeting	☐	
		☐	☐	Identified active participants	☐	
	Status	☐	☐	Covers what was accomplished	☐	
		☐	☐	Indicates problems delaying progress	☐	
		☐	☐	Outlines next steps	☐	
	Planned Questions	☐	☐	Focuses attention on the key issues	☐	
		☐	☐	Plans thoughtful questions	☐	
		☐	☐	Plans questions with sufficient depth/breadth	☐	
	Responsive Questions	☐	☐	Appropriately restates what client has said/asked	☐	
		☐	☐	Shows willingness to ask additional questions	☐	
		☐	☐	Attempts to discern true needs of the client	☐	
	Conclusion	☐	☐	Confirms meeting goals were met	☐	
		☐	☐	Reviews and confirms decisions from the meeting	☐	
		☐	☐	Identifies and articulates next steps	☐	
		☐	☐	Evaluates meeting format / flow / outcomes	☐	
	Follow-up	☐	☐	Sends recap after meeting	☐	
		☐	☐	Articulates action items and their owners	☐	
	Mindset	☐	☐	Prioritizes listening over assuming client needs	☐	
		☐	☐	Keeps an open mind and explore opportunities	☐	
		☐	☐	Demonstrates ability to cope with change	☐	
	Conduct	☐	☐	Shows respect toward client	☐	
		☐	☐	Ensures members of team participate	☐	
		☐	☐	Starts and ends meeting on time	☐	
		☐	☐	Avoids language that perpetuates knowledge gaps	☐	

INSTRUCTIONS FOR STUDENTS:
Use this rubric as both guide and checklist to assist you before, during, and after meetings with your client. Such preparation will help lead to effective meetings, making the most of your limited time with your client.

INSTRUCTIONS FOR CLIENTS:
Use this rubric as a means to evaluate student performance before, during, and after meetings with you as a client. Your expert feedback is useful as a formative evaluation tool to help students improve their professional skills related to working with clients on projects.