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Client Interaction Tools: Supporting Student Professionalism on Client-Based Capstone Design Projects*

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Effective communication between project teams and client sponsors is an essential skill for engineering students and practitioners alike. This paper outlines the three phases of the development, implementation, and assessment of two Client Interaction Rubrics and a subsequent Client Interaction Checklist to guide and support student-client interaction at the outset and throughout the duration of capstone projects. The developed resources were tested in multiple capstone design and project-based courses over three years at a total of six academic institutions. Both formal and informal assessments were conducted regarding the use of these three tools. Students were surveyed following their use of the tools and data were collected on several aspects of instrument use, content, and design with a mix of Likert and open-ended questions. These methods yielded predominantly positive feedback referencing the value of the tools in effectively preparing for, conducting, wrapping up, and following up after client meetings. Constructive feedback was used to inform and revise subsequent versions of the interaction tools for functionality and usability. All of the materials developed through this research are freely available via download, easily editable, and adaptable for use in whole or in part for capstone and similar project-oriented courses. Through the use of such tools, student engineers are better prepared and positioned for success in their interactions with clients. Likewise, effective professional interactions with project clients can build and strengthen relationships between the clients and the associated academic programs, leading to future opportunities and partnerships.

Keywords: client meeting; rubric; checklist; capstone project

1. Introduction

One of the growing trends in engineering education is the call to incorporate real-world design experiences into the curriculum, with a key aspect being student teams working with and delivering solutions to external clients [1–3]. One such approach is through the "entrepreneurial mindset" (EM) promoted by the Kern Entrepreneurial Engineering Network (KEEN) via a paradigm that features, in addition to technical fundamentals, a focus on business principles, customer awareness, and societal needs [4]. The framework of this paradigm emphasizes three educational outcomes: curiosity, connections, and creating value [5]. Those possessing such a mindset demonstrate curiosity in exploring possibilities, make connections across various sources to gain insights, and create value by persisting through failure [6]. Support for the educational and vocational value of working with clients is well documented. Whether the client is from industry, a faculty member, or another type of sponsor, the concept of interacting with and providing a deliverable to a customer has value on several levels [7–9].

The research presented here was initially motivated by efforts on the part of the lead author to improve and expand the EM content in the Computer Science program at Ohio Northern University

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(ONU). While many components of the initial EM effort in establishing service-learning partnerships by developing educational software were successful, some weaknesses were observed, the most notable being a general lack of mastery by students in interacting with clients [10]. Communicating with others, especially those outside one's profession, is an essential skill [11, 12]; unfortunately, the students had not been prepared through the curriculum for such interactions. In the aforementioned prior work, single-point rubrics [13, 14] were developed and employed as the primary means for formative assessment. The single-point rubric is characterized by providing only one descriptor for each dimension: specifically, the criterion for proficient performance. This makes rubric construction easier, as only the expectations for proficiency are now stated; the list of failures for the remaining performance levels is no longer included. Also, student interpretation of the rubric is streamlined as the rubric focuses solely on proficiency norms. Based on the positive results of these initial efforts, it was hypothesized that instituting a comparable rubric to help guide students' interactions with clients would be of value and, if successful, could also be shared with the wider educational community, including those in capstone.

Another motivator comes from the increasing role that clients play in capstone design. Statistics from the 2015 Capstone Design Survey [15] indicated that over 70% of the respondents ($n = 461$) had external sponsorship for their capstone projects. Additionally, the expectations for regular communications with clients have increased when compared with the data from the two previous decennial surveys, with most student teams now meeting at least monthly with their client, while only 7% meet strictly at the beginning and the end of the project [15]. As the percentage of local sponsors has decreased over time, and as an increase in international sponsors has occurred over that same time [15], the need for effective communication skills has taken on a more important role. Capstone coordinators are already familiar with the need for creating relationships at the client-administration level to prepare capstone sponsors for working with students via discussing scope, access, data availability, timelines, responsibilities, and goals [16]. However, there is still more to be done to prepare students on these same elements by providing tools that not only evaluate, but also guide [17]. This work widens the lens on the student-client-project dynamic, thereby helping position students for successful client interactions in capstone and beyond.

The overarching research questions for this work were as follows:

RQ1: Can an instrument such as a rubric or checklist be a valuable tool to help prepare capstone design students for interactions with external clients?

RQ2: Can such an instrument be successfully implemented in capstone design courses across a variety of institutions and program profiles?

2. First phase: Client Interaction Rubric

The Client Interaction Rubric (provided in Appendix 1) was developed using the single-point rubric format and contains eight sections selected to assist students in preparing for, facilitating, and reflecting upon meetings with clients: Preparation, Status, Planned Questions, Responsive Questions, Conclusion, Follow-up, Mindset, and Conduct. Its format 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 Client Interaction Rubric can be used by students as a guide before a meeting, during a meeting, or for post-meeting self-reflection; it can also be given to clients to evaluate student performance. This Rubric underwent multiple iterations as it was tested with students and with internal and external clients. The Rubric objectives were also validated through a survey completed by members of the ONU College of Engineering (CoE) Industrial Advisory Board.

The original version of the Client Interaction Rubric was used and tested informally during the fall 2016 semester in two environments: a junior-level user interface (UI) design course taken by both computer engineering and computer science majors at Ohio Northern University, and an engineering capstone design course at Smith College. While not a capstone-level course, UI design at ONU has capstone-like qualities in that it uses external clients as the source for semester-long projects. Additional details about the development and use of the original Rubric were presented at the 2017 ASEE Annual Conference [18].

The Client Interaction Rubric received positive reviews by students at the two institutions who used it to help guide their interactions with real-world clients. Of the 10 students (5 ONU, 5 Smith) who responded to an informal survey about their Rubric usage, nine offered comments related to what they liked most about the Rubric. For example, one student commented that the Rubric was "*surprisingly useful when preparing for meetings.*" Another noted that the open format of the Client Interaction Rubric "*allowed for the person filling it out to provide more substantial feedback.*" When asked what changes they would make to the Rubric, only one

student suggested an area for clarification; the others either noted no changes or left the question blank. The original version of the Client Interaction Rubric functioned well for client meetings in general, but it did not capture items specific to the *initial* client meeting, something noted by both students and client users. This feedback was also echoed by the ONU CoE Industrial Advisory Board, who emphasized the importance of preparing for the first or "kick-off" meeting with clients to set the tone for the project and future interactions.

3. Second phase: Initial Client Meeting Rubric

Informed by the feedback from the first phase, the ONU and Smith authors joined forces with the Northeastern University (NU) author in summer 2017 to create a version of the Client Interaction Rubric specifically tailored for first meetings. The development of the Initial Client Meeting Rubric focused on four primary objectives:

1. Providing guidance for the initial client interaction in accordance with project priorities,
2. Developing a working relationship with the client based on clarity, confidence and trust,
3. Establishing project scope and early success metrics [19], and
4. Serving as a teaching and reflection tool for the student teams [20].

Thus, the rubric development process sought to form a chronological framework with a conversational substructure. The Initial Client Meeting Rubric (provided in Appendix 2) follows a general sequence of activities and can guide the initial client meeting preparation, agenda format and tone, and follow-up interactions. This Rubric maintains the same general format as its predecessor, the Client Interaction Rubric, adding sections that focus specifically on the initial meeting, namely Preparation, Project, Team, Logistics, Interaction, Conclusion, Follow-up, and Conduct. The next step was to introduce the Rubric across multiple academic settings at varying levels of use.

3.1 Survey results on initial client meeting activities and preparation

The inaugural deployment of the Initial Client Meeting Rubric occurred with the fall 2017 capstone courses at ONU, Smith, and NU; this Rubric was distributed prior to any interactions with clients of capstone projects. To determine the Rubric's value and relevance, a survey was constructed focusing on the overarching theme of studying capstone projects involving clients. Following questions about institution, team size, project title and type, the survey comprised 14 components about planning for, interacting with, and following up with the client or sponsor. The format was a combination of dropdown selections, yes/no responses, requests for numeric values, Likert-scale statements about their level of comfort with various aspects of the interaction process, and open-ended responses. Capstone Coordinators provided a link to the survey and students completed it outside of class within a few days of receiving the request. This research presents the findings from a select subset of these questions as outlined below.

This survey was completed by individual capstone students at all three institutions (NU: $n = 22$ students, ONU: $n = 46$ students, Smith: $n = 15$ students). Table 1 lists the survey questions discussed in this paper. Teams at all three institutions generally consisted of 4–5 student members each working on a wide range of projects including non-profit agencies, small businesses, large-scale corporations, hospitals, community partners, and var-

Table 1. Selected Survey Questions Regarding Initial Client Meeting Activities and Preparedness

Survey Question	Response Choices
Who initiated the first contact between your team and your client/sponsor?	A member of our team, Client/Sponsor, Capstone/Project Coordinator, Faculty Advisor/Coach, Other (please specify).
Which of the following activities did you and your team do in preparation for your initial client/sponsor meeting? Check all that apply.	Created an agenda, Made a checklist, Developed talking points, Researched the company/organization, Researched competitors and/or comparable organizations, Researched the client attendees, Other (please describe), None of the above.
Please indicate your degree of comfort with performing the activities below associated with the initial meeting: Initiating/scheduling the meeting, Preparing for the meeting, Following a meeting agenda, Participating in the meeting, Articulating next steps, Wrapping up the meeting, Following up after the meeting.	(For each activity): Extremely uncomfortable, Somewhat uncomfortable, Neither comfortable nor uncomfortable, Somewhat comfortable, Extremely comfortable.
What items/concepts/skills do you wish you had known prior to preparing for and/or participating in this initial client/sponsor meeting?	Open-ended response.

ious government entities as external clients; internal clients included faculty members and university organizations.

3.1.1 First contact with client

A notable activity that must occur prior to the initial client meeting is making "first contact" between students and client, usually for the purpose of establishing arrangements for the initial meeting. Using a multiple-choice selection query, the survey results ($n = 79$) indicated that 53% of the time a team member (rather than faculty members or clients) initiated first contact, suggesting that students need to be prepared for this type of responsibility. For those respondents indicating that a team member made the first contact, the initial client meeting was usually held within one week after the first contact and within two weeks of having received the project. It was also generally the case that all team members attended the initial client meeting, which is recommended.

3.1.2 Preparation for initial client meeting

One of the survey questions used check boxes to ask students to identify which activities they engaged in to prepare for their initial client meeting. Of those responding to this question ($n = 73$), most notably 94% indicated that they developed some form of meeting guidance document, and 63% indicated that they conducted some form of preparatory research about the company, the individual clients and/or associated product or service.

3.1.3 Comfort levels navigating the initial client meeting

Using a 5-point Likert scale, students were also asked about their comfort levels for the outcomes associated with the first seven sections—all except Conduct—listed in the Initial Client Meeting Rubric. The reported ($n = 79$) *discomfort* levels were consistently low across all outcomes, ranging from 8% to 12%, while the *comfort* level in each case was at least 76%, with the most comfortable activity, "preparing for the meeting," coming in at 87%. In retrospect, most students (75%, $n = 79$) indicated that in their opinion nothing was overlooked, not covered, or not addressed during their initial client meeting; however, a general theme from the minority responses indicated questions remained regarding project scope, desired clarifications, and specifics regarding objectives and timelines.

3.1.4 Wished had known before initial client meeting

In terms of what students wished they had known prior to the meeting, an informal word cloud of the open-ended responses illustrated a dichotomy between "none" and "research". Regarding research, students indicated a further need for having "*a better grasp on knowing how to properly research related literature*," performing "*some prior research on the company and the liaison*," knowing "*more about the client prior to the meeting*" as it affected that respondents' expectations, and for having "*a better understanding of the project*" so that more in-depth questions could have been constructed.

Among the additional responses were such items as "*probably need to work on social skills*" (as this respondent used the wrong company name multiple times during the meeting), a need for how to politely interrupt domineering participants "*to move along a meeting and keep it within a set time*," and a desire for a "*more developed problem statement*" that included some of the basic technical terms used by that client.

3.2 Feedback on initial client meeting rubric value and format

Halfway through their capstone experience, four project teams from ONU, ten project teams from NU, and nine project teams from Smith were surveyed regarding their experience with the Initial Client Meeting Rubric and their suggestions for improving the Rubric for future classes/teams. Quantitatively, the student teams found most value in using the Initial Client Meeting Rubric to prepare for the initial client meeting, with 90% of the respondents in agreement, as shown in the top graph in Fig. 1. As seen in the bottom graph of Fig. l, responding teams would recommend using the Rubric again with future teams.

Supporting their Likert-scale ratings, teams provided such comments as "*The rubric is really helpful to prepare a team who has no idea what they are getting into*" and "*Helpful in terms of expectations for meetings and getting started talking to liaisons*". When asked what they liked most about the Initial Client Meeting Rubric, student comments included responses such as "*we like that it covers different areas to cover during the meeting*", "*the instructions for each party were very helpful*", and "*the descriptions are brief and to the point*". One team noted that having the Rubric meant that "*the team did not have to decide our own standards*", something that may well be valuable, especially so early in a project experience.

Queries on the value of the Initial Client Meeting Rubric as a reflection tool yielded mixed opinions. Comments included "*rubric was useful in figuring out next steps*" and "*helped us identify what we may have missed*", but several teams noted that they did not revisit the Rubric later or did so only quickly and did not find it useful in that capacity. Several teams noted that their meeting format was not as

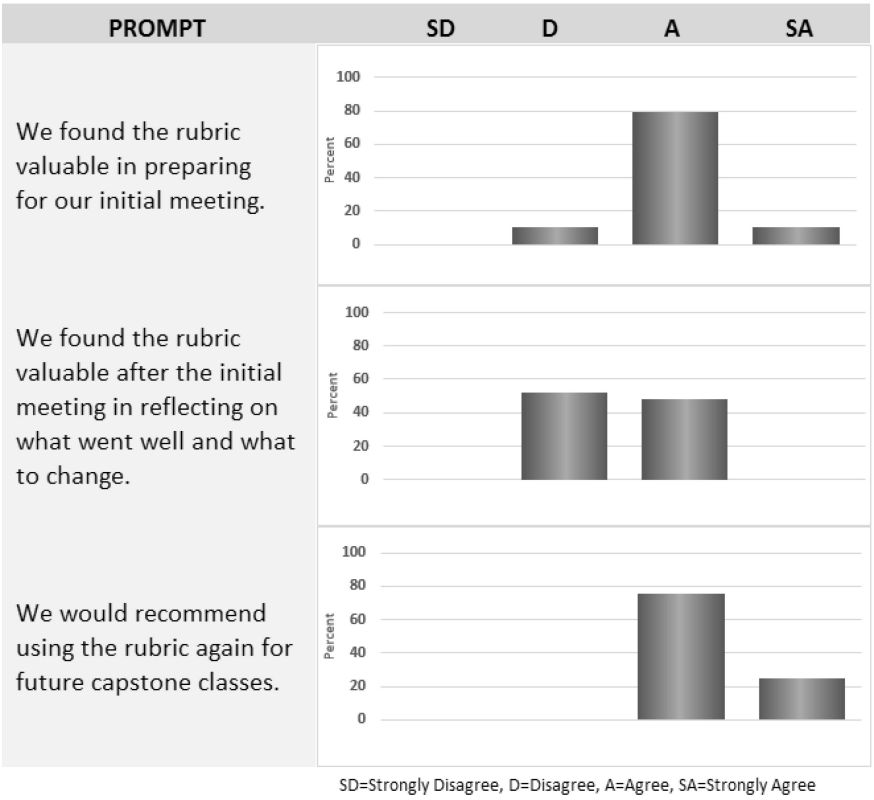

Fig. 1. Student Feedback on Perceived Value of Initial Client Meeting Rubric (n = 23 *teams*).

formal as the Rubric suggested, thus it was not fully applicable. It is possible that these results are merely indicative of the students' general inclination to reflect (or not reflect). A few teams suggested getting liaison feedback on their performance as an additional input for reflection; this was one potential function for the Initial Client Meeting Rubric, but was not implemented during the pilot usage.

The student teams were also asked to provide open-ended feedback on the Initial Client Meeting Rubric contents, format, and wording. In particular, students were asked "What improvements would you recommend to make a Student-Client Interaction Rubric more useful? Please mark up the attached rubric to reflect your proposed improvements." A multirater content analysis was conducted on the students' open-ended feedback and associated rubric edits to identify and quantify emerging themes [21]. Two raters independently coded the responses across 5–7 categories, one of which could be designated as "miscellaneous" or "general". Five common categories were then collaboratively identified, followed by creation of the category of "Suggestions/Formatting Ideas/Elements to Add". There were 68 specific comments from 23 sets of responses. These responses were organized into a Pareto chart, falling into six general categories for redesign consideration as shown in Table 2.

Table 2. Top Categories for Student-Suggested Edits on Initial Client Interaction Rubric

Student Recommendations for Rubric	% of Respondents (n = 23)
Make wording and format more concise	65%
Remove unnecessary or N/A items	61%
Refine or adjust the "Meets Expectations" area	52%
Clarify or explain concepts and/or language	48%
General suggestions, ideas, and formatting	43%
Consider client's perspective	26%

Several general comments offered ideas for items to add or reword across the Initial Client Meeting Rubric, but no prevailing theme was identified here.

4. Third phase: Client Interaction Checklist and extended deployment

In response to student feedback about using the Rubric as a checklist and condensing the general content, the ONU/Smith/NU authors also created a simplified Client Interaction Checklist format in summer 2018. This Client Interaction Checklist (provided in Appendix 3) provides a visual representation of both the Initial Client Meeting Rubric and its companion Client Interaction Rubric on the same form in a single-page checklist format without space for comments. The Checklist under-

went several internal revisions for formatting and wording before being distributed for use by students.

Building on presentations of the second phase work and interactions at the 2018 Capstone Design Conference and ExCEED Teaching Workshop, the ONU/Smith/NU authors recruited capstone faculty from three additional institutions—Colorado School of Mines (Mines), University of Vermont (UVM), and Rose-Hulman Institute of Technology (Rose)—to participate in an extended deployment of the Initial Client Meeting Rubric and the new Client Interaction Checklist in fall 2018. Table 3 provides demographic information about all six institutions and their engineering programs. Collectively, these institutions represent diverse approaches to undergraduate engineering education.

Table 3. Demographics of Participating Institutions in the Third Phase

	ONU	Smith	NU	Mines	UVM	Rose
Type	Private	Private	Private	Public	Public	Private
Location	OH (USA)	MA (USA)	MA (USA)	CO (USA)	VT (USA)	IN (USA)
Number of Students*	3,100 (tot) 97 (EGR)	3,000 (tot) 44 (EGR)	19,800 (tot) 700 (EGR)	6,000 (tot) 1,099 (EGR)	12,900 (tot) 207 (EGR)	2,400 (tot) 497 (EGR)
Undergrad Profile**	Balanced Arts & Sciences + Professions	Arts & Sciences Focus	Balanced Arts & Sciences + Professions	Professions Focus	Balanced Arts & Sciences + Professions	Professions Focus
Undergrad Duration	4 years	4 years	5 years***	4 years	4 years	4 years

* Number of students provided for institution overall (tot) and 2018 engineering (EGR) graduating class size.
** Undergraduate profile per the Carnegie Classification website: http://carnegieclassifications.iu.edu.
*** Includes two or three 6-month co-op experiences in industry.

Table 4. Capstone Course Profiles at the Participating Institutions

	ONU	Smith	NU	Mines	UVM	Rose
Capstone Duration	2 semesters: fall start only	2 semesters: fall start only	2 semesters: sequential or with 6-month co-op interval	2 semesters: fall or spring start	2 semesters: fall start only	3 quarters: fall or spring start
Capstone Structure	Department-specific lectures and common lab	Program- specific lectures and projects in parallel	Lectures and projects in parallel	Interdisciplinary lectures, recitation, and projects in parallel.	Interdisciplinary lectures and projects in parallel	6–7 separate sections run independently with common rubrics
Engineering Capstone Disciplines (in study)	Civil, Computer Engineering, Computer Science, Electrical, Mechanical, Engineering Education	Engineering Science	Industrial, Mechanical	Civil, Electrical, Environmental, Mechanical	Biomedical, Electrical, Mechanical	Mechanical
Project Sourcing*	Internal and External	External	Internal and External	External	Internal and External	Internal and External
Capstone Advising	All faculty advise one team annually	Course instructor advises all teams	Two course coordinators; 1–3 teams for each faculty advisor	Five faculty run course; teams also have project advisors	Course instructor and faculty mentors	Section instructor mentors that section's teams
Avg. Team Size	3–4	3–4	4–5	4–5	4	3–7
Avg. # of Projects	20–25	8–9	19–20	80–90	30	40–45

* Internal refers to projects within the institution; External refers to projects outside the institution, which could include industry, government, community organizations, NGOs, hospitals, and competitions.

4.1 Deployment logistics at participating institutions

The capstone faculty contacts at each of the six institutions in the extended implementation effort were provided with the Initial Client Meeting Rubric and the Client Interaction Checklist at the start of the fall 2018 semester and were requested to deploy either/both as best fit their capstone course environment and their pedagogical needs. Specific information about the capstone course profiles and deployment strategies for each institution are detailed in Tables 4 and 5. The capstone courses all feature student-client interaction experiences, but differ in their course structures and pedagogical logistics. Moreover, the capstone contacts employed a variety of strategies for implementing the Rubric/Checklist, ranging from simply making the tools available to crafting an interactive lesson plan around them.

4.2 Analysis and feedback

After the Initial Client Meeting Rubric and Client Interaction Checklist were deployed at the six participating institutions as described above in Table 5, all student teams had some form of initial meeting with their client/sponsor. Following those meetings, the students at all six institutions were surveyed about their use (or not) of the two tools, their experiences before and during the meeting, and their reflections regarding what they wished they had known and what they realized they had overlooked. Table 6 lists the relevant survey questions and response choices discussed in this paper. The first survey question and its response choices have been edited to reflect the current names of the tools used in the paper.

4.2.1 Access to and use of Rubric or Checklist

Of the 189 students who completed this survey, 124 (65%) reported that they were provided with a copy of the Initial Client Meeting Rubric or Client Interaction Checklist prior to their initial client meeting. Of those, approximately one-third reported that they received the Rubric, one-third received the Checklist, and one-third received both. When asked to what extent they used the Rubric or

Table 5. Tool Deployment at the Participating Institutions

Institution (# students in study)	Tool Used (Checklist or Initial Meeting Rubric) and Deployment Description
ONU (87)	**Checklist**: The Checklist was posted on the Moodle course management system and announced to students as a resource before students had their initial client meetings. How and to what extent students utilized the Checklist was left up to each team; there was no requirement put forth by any of the capstone team advisors to use or adopt this resource.
Smith (35)	**Checklist**: The Checklist was distributed in hard copy (with electronic copy also on the Moodle course management system) and discussed during a class on meeting practices. Teams were encouraged to reference the Checklist when preparing for their kick-off meeting with project liaisons. The course instructor did not provide any formal assignment related to the Checklist, but did informally debrief the kick-off client meetings with each team the following week.
NU* (59)	**Rubric**: (1) A subset of teams was provided the Initial Client Meeting Rubric to use as a guideline for their work with clients. (2) Another subset of teams completed a classroom exercise prior to seeing the rubric in which they outlined their preparation, agenda, and follow-up plans for their initial client meeting, first individually and then in teams. The Initial Client Meeting Rubric was then provided to each team, and the students finalized their outlines by adding elements from the Rubric that no one had thought of, and then used their outlines to guide next steps for the client meeting. This exercise also served to identify commonalities, gaps, concerns, and priorities.
Mines (400)	**Checklist**: The Checklist was distributed via the course CANVAS course management site as well as via email, with the instructions being to treat the Checklist as a guide to follow for the first client interaction. The Checklist was also highlighted during a lecture focused on professional communication skills. Students were strongly encouraged to use the Checklist to prepare for their initial client meeting but no distinct assignment was linked to the Checklist.
UVM (125)	**Checklist**: The Checklist was distributed in paper and electronic format to the class as a helpful tool to guide the first client interaction. The teams were asked to review the Checklist and use it to prepare, conduct, and reflect on the first client meeting. This happened in conjunction with a lecture on communication skills and strategies to interact with the client, team members and faculty advisor.
Rose (24)	**Checklist**: The Checklist was introduced along with other fall quarter expectations after projects were assigned and before students initiated contact with their sponsors. The Checklist was provided both as a hard copy and posted on the Moodle course management system. The instructor recommended using the Checklist but did not require students to submit any evidence of using it; students were expected to refer to the information as needed. General feedback independent from the Checklist was also provided to all students after their first client interaction. Several weeks later, a survey was administered during class time to solicit how the students' interactions with their client were going. The holistic survey results were presented to the class in the form of good practices observed, common mistakes observed, and improvements for future interactions.

* Note: NU also included two control groups who did not use the Rubric, but were given the feedback survey about their project preparations and client interactions. One control group started capstone directly after a semester of classes; the other started capstone directly after a 6-month co-op experience.

Table 6. Selected Survey Questions Regarding Use of Tools and Meeting Experiences and Reflections

Survey Question	Response Choices
In preparation for your initial meeting, were you provided with a copy of either (a) the Initial Client Meeting Rubric, and/or (b) the Client Interaction Checklist? Please select all that apply.	Yes with the Initial Client Meeting Rubric, Yes with the Client Interaction Checklist, No.
To what extent did you use the provided rubric/checklist?	Followed nearly identically, Followed closely, Used as a guide, Used to suggest some ideas, Hardly used or followed it, Did not use it.
Please indicate your degree of comfort with performing the activities below associated with the initial meeting: Initiating/scheduling the meeting, Preparing for the meeting, Following a meeting agenda, Participating in the meeting, Articulating next steps, Wrapping up the meeting, Following up after the meeting.	(For each activity): Extremely uncomfortable, Somewhat uncomfortable, Neither comfortable nor uncomfortable, Somewhat comfortable, Extremely comfortable.
After the initial meeting, was there anything you realized was overlooked, or wished you had covered or addressed, during that meeting?	Yes, No.
Please elaborate on what was overlooked, not covered, or not addressed.	Open response.
What items/concepts/skills do you wish you had known prior to preparing for and/or participating in this initial client/sponsor meeting?	Open response.

Checklist they were provided, a total of 93% of those respondents reported using it to some extent: 55% reported using the Rubric or Checklist "as a guide", another 16% used it to "suggest some ideas", another 15% "followed it closely", and an additional 7% of respondents reporting "following it nearly identically".

4.2.2 Level of comfort in executing key aspects of initial client meeting

The survey also asked respondents to report their comfort level with the various aspects of planning, conducting, and following up with the initial meeting with their client or sponsor. The Likert-scale responses were analyzed using Chi-Square analyses to compare between respondents who had either the Rubric or Checklist to those who did not; the results are presented in Table 7. The categories of 'Somewhat uncomfortable' and 'Extremely uncomfortable' were collapsed together to meet the recommended Chi-square minimum of five observations per cell. In general, students were quite comfortable with or without the Rubric or Checklist when it came to contacting the sponsor, planning for the meeting (including creating an agenda), adhering to the agenda as set out, and following up afterward with the client. Chi-square analyses detected no significant differences between those who used the Rubric or Checklist for those three activities. A key finding is that those who had access to the Rubric or Checklist ($n = 124$) were significantly *more* comfortable with articulating the next steps to take as contrasted with those who did not have such a tool to assist them χ^2 (3, $n = 65$) = 7.846, $p = 0.049$. Conversely, those without the Rubric or Checklist were significantly *less* comfortable wrapping up the meeting as contrasted with those who had one of the Rubric/Checklist tools χ^2 (3, $n = 65$) = 9.681, $p = 0.021$. The latter already had steps in place to comfortably bring the meeting to a conclusion.

4.2.3 Elements overlooked in initial client meeting

The survey also asked in a "yes/no" question whether after the initial client meeting there was anything that the teams realized they had overlooked or wished they had covered or addressed during that meeting. Analysis of the data reveals that no significant differences were found among teams who had access to either the Rubric or Check-

Table 7. Analysis of Respondents' Comfort Level with Meeting-Related Tasks with and without the Rubric or Checklist

Task	Outcomes: χ^2 (3, $n = 189$)	p-value	χ^2 Statistic
Preparing for the Meeting	NSD	0.836	0.8559
Following the Agenda	NSD	0.606	1.8434
Articulating Next Steps	*Significant at $p < 0.05$*	*0.049*	*7.8461*
Wrapping up the Meeting	*Significant at $p < 0.05$*	*0.021*	*9.6813*
Following up after the Meeting	NSD	0.961	0.2942

NSD = No Significant Difference at $\alpha = 0.5$.

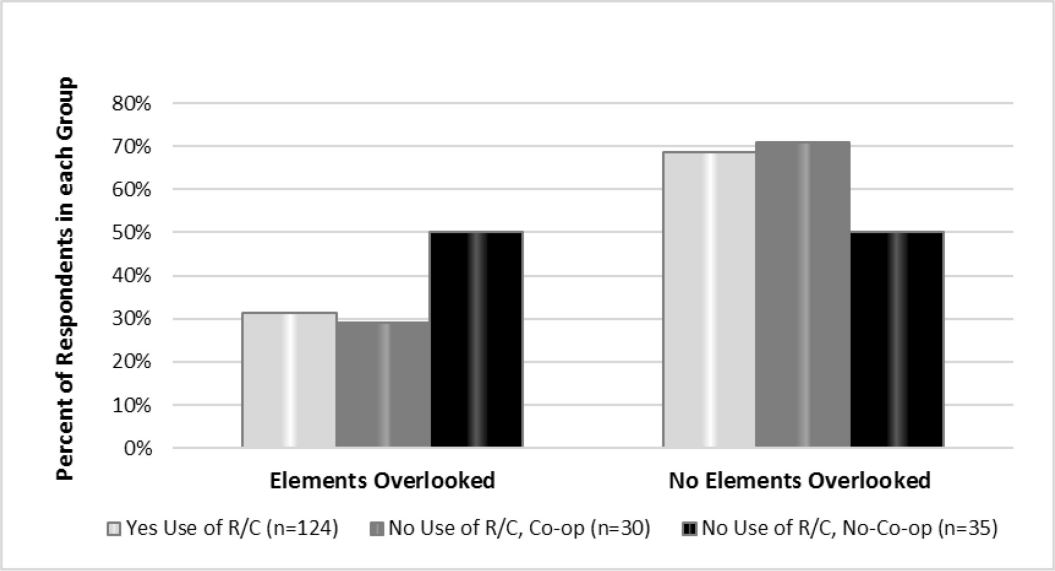

Fig. 2. Elements Overlooked by the Student Teams after the Initial Client Meeting (R/C = Rubric or Checklist).

list versus those who did not: χ^2 (1, n = 189) = 0.936, p = 0.333. This outcome initially suggests that teams who had been provided the Rubric or Checklist reported overlooking items to the same degree as those who prepared for the initial client meeting on their own. However, further analysis of the results according to whether students had recent work experience in professional settings, such as co-op, explored the effects of prior professional practice on interaction outcomes. Responses of those without the Rubric or Checklist as a reference were stratified by those who were known to have just completed a co-op work experience (n = 30) versus those who had not (n = 35). The graph is presented in Fig. 2 and results are discussed below.

Fig. 2 illustrates that the profile of those with the Rubric or Checklist is very similar to that of those who had just recently been in a professional work environment (via co-op) who did not have the benefit of the Rubric or Checklist as a resource. These two samples are found to be statistically similar χ^2 (1, n = 154) = 0.106, p = 0.745. Those students with previous exposure to managing goals, agendas, challenging discussion items, and stringent time frames more readily included the relevant tasks and items when it came to preparing for and executing a client meeting. Some representative quotes from recent co-op students include the following: "*I regularly do [the items] with all of my meetings*" and "*All of us had had professional interactions by this point.*"

4.2.4 Wished had known before initial client meeting

Students were asked what items/concepts/skills they wished they had known prior to their initial client meeting. Using thematic analysis [21, 22], four primary patterns emerged for those with the Rubric or Checklist (R/C, n = 132) and those without (No R/C, n = 42). Namely, of the responses, there were:

1. Those who wished for more *guidance in meeting conduct* and flow, confidence and leadership, and establishing scope and roles (No R/C: 11%, R/C: 29%),
2. Those who wanted to have more *technical background* to help with meeting preparation (both just at ~16%),
3. Those who expressed a desire for more *project or client background* (~18% of responses in both cases), and
4. Select few who specifically wished they had done better to *prepare an agenda/plan* (No R/C: 7%, R/C: 6%).

In both cases of R/C and No R/C, nearly one-third felt sufficiently prepared for the interaction (~32% for both).

In terms of meeting execution and flow, multiple respondents noted they wished they had been instructed on interpersonal skills, especially within meetings. For example, "*It would have been nice to learn some group dynamic skills because there were awkward silences where the PM wanted other members to speak, but the other members did not want to intrude on the PM's leading of the meeting*" and "*Skills like meeting control would be valuable. Also how to address concerns respectively would be helpful.*" It is very interesting that those who had the rubric wanted much more in terms of

meeting conduct, leadership, role-setting, and related professional elements in contrast to those who did not. In this case, having the rubric may raise students' awareness to this essential set of competencies for dealing professionally with clients.

For meeting preparation, students expressed a desire to have known more specifics about their project in advance—"*a more detailed project description*"—and to have more relevant technical skills related to the project: "*I wish I had known more about manufacturing engineering*" and "*a better knowledge of dynamics*". Some students—both those who had access to the Rubric or Checklist and those who did not—wished they had created an agenda to be better prepared.

Other students would have liked guidance on meeting logistics such as note-taking: "*I wish we had known to write all the details down that they told us. These little details will be important later and the documentation wasn't there the first meeting*". While some students wished they had a prepared agenda in hand as noted above, others commented that their agenda was too specific: "*I wish I had known to just be prepared for the meeting to not follow the agenda exactly, especially since we had a really detailed agenda.*"

As noted, approximately 32% of all responses provided by students cited "*None*", "*Nothing*", or "*N/A*", indicating there was nothing in particular they wished they had known prior to their initial client meeting. Some students went on to clarify that they already felt prepared because of prior work experience: "*Co-op fully prepared me for the meeting.*" and "*None. This was a very straightforward meeting. Anyone that has ever worked a day in their lives should have felt okay with this meeting.*"

4.2.5 Student input on refining the Rubric

As part of the Rubric implementation at NU, students created a plan and an agenda in a guided activity before seeing the Initial Client Meeting Rubric. Eight teams of 4–5 members each conducted this exercise. They then assessed their plans and agendas in light of the Rubric contents. Likewise, they evaluated the Rubric while referencing their planning outlines. A review of the items that students included prior to referencing the Rubric suggests some items that could be added to future versions of the Rubric to improve its utility as a guiding document.

In the aforementioned activity, there were several items that students had placed on their planning agenda that were not already included on the Rubric. These items generally fell into four categories, as listed below, with 50% or more of the teams independently including them:

1. *Orientation*: Conduct introductions and site visit.
2. *Impressions and Boundaries*: Establish contribution level/initiative, outline rules and constraints.
3. *Problem Overview*: Explore existing problem/past solutions, set short-/long-term goals, identify timeline.
4. *Technical Requirements*: Identify skills and tools needed and determine data availability/collection.

This pilot exercise will be replicated across several programs and re-evaluated to help inform subsequent versions of the Initial Client Meeting Rubric.

4.2.6 Observations and anecdotal outcomes from students and faculty

Faculty members at some of the participating institutions were able to capture anecdotal observations regarding their students' use of either the Initial Client Meeting Rubric or the Client Interaction Checklist. First and foremost, the feedback was overwhelmingly positive; students appreciated having a document that allowed them to successfully navigate a new type of engineering interaction. Many students stated that the document encouraged them to be prepared and organized when planning for the meeting, as it gave a framework for the type of communication and behavior generally expected when meeting with a client, especially for the first time. Other students liked that it was more than just an agenda, as it also outlined planning and setting up the meeting, navigating topics, wrapping up, creating a vision for going forward, and following up afterwards. Various project advisors and clients (especially repeat clients) have mentioned that using these tools allowed the students to think and behave like seasoned engineering consultants and that a distinct improvement in the initial client meeting was observed in comparison to previous years.

Suggestions and feedback on the Initial Client Meeting Rubric contents and its use related to how extensive the Rubric appeared to be. This created a form of dissonance between the students' inclination to follow it exactly and their simultaneous resistance to following it exactly, since not all parts applied to their project, situation, or meeting tone. This dissonance can be managed by being mindful of how the Initial Client Meeting Rubric (and its use) is introduced as a tool by the instructors and coordinators who provide it.

It is worth noting here that some students found their initial client meetings to be much more informal than they were led to expect, but overall they appreciated the variety of elements presented in

these resources. One of the teams even voluntarily used the Client Interaction Checklist before submitting their end-of-term report to their client, thus indicating the students' desire for and use of supporting tools to assist with client interactions. An additional suggestion made for improvements was that some students believed that they would find the documents to be more valuable if they were able to customize them and choose (or remove) items as they deemed relevant to their comfort level and client profile.

5. Conclusions

This work was motivated by two overarching research questions: (1) Can an instrument such as a rubric or checklist can be a valuable tool to prepare capstone design students for interactions with external clients? and (2) Can such an instrument be successfully implemented in capstone design courses at a variety of institutions?

This paper reports on a set of three tools developed to support interaction between project teams and clients at the outset and throughout the duration of capstone projects. The tools include a general Client Interaction Rubric, an Initial Client Meeting Rubric specifically for first client meetings, and a Client Interaction Checklist that addresses both initial and ongoing meetings (full versions in Appendices 1–3). The tools were successfully tested in capstone design courses at six institutions with different capstone design formats and various deployment strategies.

Student feedback to both the Rubrics and Checklist was positive. Most students (93%) reported using the Rubrics and Checklist as a reference to prepare for their initial client meetings, with usage ranging from a source for ideas to a tool to follow directly. Students who had access to the Rubrics or Checklist were more comfortable in articulating next steps and wrapping up their meetings. Data analysis from this work suggests that having either a Rubric or a Checklist results in fewer key elements being overlooked in the meeting and reveals desire from students to further develop professional skills to enhance client interactions. Additional data are being compiled across a variety of Capstone scenarios to further evaluate these trends.

Key objectives are for the tools to free up the students' attention so that the students may be fully present for the meeting discussions, and to be comprehensive enough to be used as a guide, but not so complex that they detract from the meeting at hand. Student feedback has informed the evolution of these tools, specifically the more compact Client Interaction Checklist format; recent student comments suggest future revisions to the tools as well as the types of additional support students desire in preparing for and executing client interactions. The tools may be especially useful for students who have not had prior industry interactions through internships or co-op experiences.

Capstone instructors are encouraged to implement these tools in their own capstone design courses as a resource for their students. The editable tools are available for electronic download from CDHub (www.cdhub2.org) or by request from the lead author. This paper also provides documentation of different ways to provide students with the tools, ranging from posting the tools on a course management platform to conducting an in-class activity around the Initial Client Interaction Rubric. As the student feedback showed, explicitly framing the instructions on using the Rubrics or Checklist will help the students understand that they do not need to use all parts of the tool. For both utility and buy-in, it is important to emphasize to the student teams that the Rubrics and Checklist are for their use, as is fitting and suitable for their project and client.

6. Future work

Future work includes additional studies on the impact on learning as well as expansion to different settings. While the results from this research indicate that students recognize the value of the Rubrics and Checklist and feel better prepared for some aspects of client interaction when supported by a tool, future work could further confirm the impact on student performance as a result of Rubric or Checklist usage. This work has also raised awareness of the valuable role of co-op experiences in preparing students to conduct professional and effective interactions with clients and sponsors around open-ended projects. The Rubrics and Checklist are also applicable to students in other courses with external connections; expansion of the Rubrics and Checklist to first-year design courses with client-based projects would be a logical next step.

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Appendix 1—Student-Client Interaction Rubric

Student-Client Interaction Rubric: Regular Meeting

(see other side for instructions and guidelines)

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

		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	
Performance Objectives	Preparation	☐	☐ Identified scope of meeting	☐	
		☐	☐ Identified participants for meeting	☐	
		☐	☐ Scheduled meeting in advance	☐	
		☐	☐ Sent or requested materials in advance	☐	
		☐	☐ Provided discussion topics/agenda ahead of time	☐	
	Status	☐	☐ Covers what the team accomplished	☐	
		☐	☐ Indicates problems delaying progress	☐	
		☐	☐ Outlines next steps	☐	
	Questions	☐	☐ Focuses attention on the key issues	☐	
		☐	☐ Plans thoughtful questions	☐	
		☐	☐ Plans questions with sufficient depth/breadth	☐	
	Interaction	☐	☐ Appropriately restates what client/sponsor said	☐	
		☐	☐ Asks additional questions where relevant	☐	
		☐	☐ Attempts to discern true needs of client/sponsor	☐	
	Conclusion	☐	☐ Confirms meeting goals were met	☐	
		☐	☐ Reviews and confirms decisions from the meeting	☐	
		☐	☐ Identifies and articulates next steps	☐	
		☐	☐ Evaluates meeting format, flow, and outcomes	☐	
	Follow-up	☐	☐ Sends recap after meeting	☐	
		☐	☐ Reiterates next steps, action items, and owners	☐	
	Mindset	☐	☐ Prioritizes listening over assuming others' needs	☐	
		☐	☐ Keeps an open mind and explores opportunities	☐	
		☐	☐ Demonstrates ability to cope with change	☐	
	Conduct	☐	☐ Shows respect toward client/sponsor and team	☐	
		☐	☐ Ensures team members participate productively	☐	
		☐	☐ Starts, moves through, and ends meeting on time	☐	
		☐	☐ Avoids language that perpetuates knowledge gaps	☐	

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Appendix 2—Initial Client Meeting Rubric

Student-Client Interaction Rubric: Initial Meeting

(see other side for instructions and guidelines)

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

		Rating for Student Team Check one per row, or strikethrough text if not relevant			Comments Provide comments for each objective section, especially for performance marked above or below expectations
		Above	Meets Expectations	Below	
Performance Objectives	Preparation	☐	☐ Confirmed meeting time, length, mode, location	☐	
		☐	☐ Read project brief provided by client or faculty	☐	
		☐	☐ Researched company/organization	☐	
		☐	☐ Researched competitors and comparable orgs	☐	
		☐	☐ Identified client/sponsor attendees	☐	
		☐	☐ Researched client/sponsor attendees	☐	
		☐	☐ Planned discussion topics/agenda for meeting	☐	
	Project	☐	☐ Discusses client/project needs and context	☐	
		☐	☐ Discusses key stakeholders beyond client/sponsor	☐	
		☐	☐ Defines expectations/what constitutes success	☐	
	Team	☐	☐ Outlines relevant client/student experience	☐	
		☐	☐ Reviews roles/responsibilities of students/client	☐	
	Logistics	☐	☐ Discusses modes for sharing info and resources	☐	
		☐	☐ Confirms funding sources/amount (if applicable)	☐	
		☐	☐ Addresses relevant legal issues (IP, NDA, HIPAA)	☐	
	Interaction	☐	☐ Appropriately restates what client has said/asked	☐	
		☐	☐ Asks additional questions where relevant	☐	
		☐	☐ Explores opportunities and alternatives with client, keeping an open mind	☐	
		☐	☐ Demonstrates ability to realign/redirect regarding disparity in expectations or communication	☐	
	Conclusion	☐	☐ Confirms that meeting goals were met	☐	
		☐	☐ Reviews and confirms decisions from the meeting	☐	
		☐	☐ Articulates next steps, action items, and owners	☐	
		☐	☐ Evaluates meeting format, flow, and outcomes	☐	
	Follow-up	☐	☐ Sends thank you for initial meeting	☐	
		☐	☐ Sends recap after meeting	☐	
		☐	☐ Confirms plans for scheduling next meeting	☐	
	Conduct	☐	☐ Shows respect toward client and associates	☐	
		☐	☐ Ensures team members participate productively	☐	
		☐	☐ Starts, moves through, and ends meeting on time	☐	
		☐	☐ Avoids language that perpetuates knowledge gaps	☐	

Version 2.6 – 090617 – J. Estell, S. Howe, K. Jaeger

Appendix 3—Client Interaction Checklist