An Uncharted Territory: Removing Dependency on Grading Rubric in Senior Design Projects

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Abstract:

In the landscape of engineering education, rubrics serve a dual purpose—they function as vital tools for streamlining instructor evaluation and provide indispensable guidelines for students to establish and meet expectations. Despite this dual role, there is a potential drawback: the unintentional hindrance of critical thinking skills in students. This complexity is particularly accentuated in senior design courses, crucial for students transitioning to industry. To address this challenge, this Work in Progress introduces a case study within the Electrical and Computer Engineering senior design capstone. The study involves providing a rubric for the Preliminary Design Review (PDR) while deliberately omitting it for the Critical Design Review (CDR) presentation. Through guided workshops, students construct internal rubrics, fostering effective data presentation practices. Ongoing efforts aim to introduce a design intervention in removing rubric dependency to stimulate critical thinking and enhances information selection for presentations. The ultimate objective is to empower students to design personalized rubrics, promoting adaptability and effective communication. The paper advocates for reconsidering the prevailing use of rubrics in students' project presentations, highlighting the benefits of a more flexible and student-centric approach.

Introduction:

In the realm of engineering education, the use of rubrics for assessing senior-level data and information presentation, particularly in courses like senior design capstone, has become a common practice. While rubrics provide structured frameworks, enhancing fairness and transparency, there is a growing body of literature and critics who challenge their universal application. Many publications, ranging from the general idea of rubrics [1-2] to concerns about ill-designed and poorly implemented rubrics being more harmful than beneficial, underscore the need for a nuanced examination of their role [4].

In addition to these criticisms, a considerable body of literature argues that sharing explicit criteria with students, a fundamental aspect of rubrics, is inadequate and can lead to unintended consequences. Scholars such as Sadler [5] and Torrance [6] suggest that providing explicit assessment criteria may inadvertently foster "criteria compliance" and instrumental learning among students [6]. These concerns also extend to potential negative effects on teachers, teaching methods, or students. Such critiques have far-reaching implications for the use of rubrics, given that they represent one of the most prevalent ways of communicating explicit assessment criteria to students.

These critical perspectives coexist with accumulated empirical support for mainly positive effects of rubrics. The tension between the established benefits and emerging critiques forms the backdrop of our exploration into the role of rubrics in senior-level engineering education. This paper delves into an experimental approach that questions the conventional reliance on rubrics, aiming to foster a deeper understanding of self-assessment and cultivate skills essential for the dynamic demands of the professional world. Drawing inspiration from the works of educational scholars who emphasized experiential learning and advocating for a balanced approach, this paper delves into pedagogical strategies that transcend the structured confines of rubrics [7-8]. It explores the hypothesis that intentional exposure to assessment scenarios without rubrics fosters the development of essential skills for the dynamic demands of the professional world.

However, as the literature reveals, this reliance on rubrics raises a critical question: **do they serve as a constructive tool, simplifying the evaluation process for instructors, or do they inadvertently act as a crutch, impeding students' critical thinking skills**. Alfie Kohn, a notable critic of traditional grading practices, contends in his work that grading, and by extension rubrics, can undermine intrinsic motivation and hinder the development of a genuine love for learning [2]. By shifting the focus from grades to meaningful learning experiences, educators can create a more supportive and inclusive learning environment conducive to exploration, creativity, and critical thinking. As advocated by Blum and Kohn [3], the concept of *ungrading* emphasizes prioritizing learning outcomes over traditional assessment metrics. This approach aligns with the student-centered principles outlined in our paper, aiming to foster deeper engagement and intrinsic motivation among students.

While rubrics offer an objective means of evaluating creativity, a quality often subjected to subjective assessments under the assumption that observers within a specific domain would generally agree on its definition, classical scholars such as Thomas Angelo and K. Patricia Cross [9] advocate for rubrics, presenting them as structured frameworks that enhance fairness and transparency while offering valuable support to students navigating qualitative assignments [10-11].

Despite the common belief that rubrics enhance student work by providing constructive feedback, students often perceive them as rigid templates dictating how to secure a good grade. This tool inadvertently encourages a checkbox mentality, fostering a fear of making mistakes rather than inspiring curiosity and a genuine desire for improvement [12-13]. Critically, the use of rubrics as grading tools can undermine timely and meaningful feedback, transforming the qualitative feedback system into a quantitative scoring mechanism [14-16]. This dual nature of rubrics, either overwhelming students with excessive details or offering vague guidance, fails to effectively support their learning and development [3].

From the inclusive education perspective, use of a poorly constructed rubric in the evaluation and assessment process becomes problematic, as rubrics may not cater to students consistently meeting requirements or those struggling across various categories. The rigidity of rubrics can

inadvertently set a ceiling for student performance, discouraging them from delivering their best work when minimal effort is sufficient to fulfill rubric criteria. This paper argues for a reevaluation of the pervasive use of rubrics in senior-level capstone projects, advocating for an approach that fosters genuine learning, critical thinking, and creativity.

This initiative aims to diminish or eliminate the use of grading rubrics in the senior year, mirroring a real-world workplace experience. While recognizing the practicality of rubrics in institutional processes like proposal evaluations, the objective is to instill independence in the future workforce, preparing them for situations where guidelines are not explicitly provided. This approach seeks to minimize the potential culture shock when transitioning to professional environments.

As educators, our responsibility extends beyond imparting knowledge to equipping students with the ability to navigate ambiguity and assess their own performance effectively. This paper aims to contribute to this conversation by presenting a case study where a rubric was intentionally omitted for the Critical Design Review (CDR) presentation in an Electrical and Computer Engineering senior design course at. By doing so, we aim to encourage students to think critically and present their work with adaptability—an essential skill set for their future roles as engineers, researchers, and industry professionals. This is not a rejection of structure but a call to liberate students from dependency on rubrics, fostering skills essential for the workforce. The hypothesis we explore posits that intentional exposure to assessment scenarios without—instructor provided— rubrics cultivates these vital skills.

The forthcoming sections will detail the methodology, results, and implications of this experimental approach, offering insights into how educators can strike a balance between the structure provided by rubrics and the necessity of preparing students for a workforce where the ability to self-assess is paramount. This exploration is not just an academic exercise; it is a deliberate step toward empowering the next generation of engineers to thrive in an ever-evolving professional landscape.

Case Study:

Rubrics are informative grid-type scoring guides that articulate and evaluate assignment expectations by setting assessment standards [17]. This tool informs students of the criteria that the reviewer is looking for in academic writing and data presentation, saving students. Rubrics help break down the expectations into categories measured by the reviewer. It has been coined that rubrics make a grader's job easier by sifting through the categories and evaluating how well students fulfilled each part of the rubric.

The senior design capstone in Electrical and Computer Engineering at The Ohio State University spans two semesters, exposing students to industry and community-sponsored projects. Organized into teams of 4-5, students undertake these projects over two consecutive semesters,

emphasizing practical, real-world experiences. Addressing the data presentation learning objective, the course integrates three significant oral presentations: the Preliminary Design Review (PDR) and Critical Design Review (CDR) in the first semester (Capstone 1) and the Final Design Review (FDR) at the second semester's conclusion (Capstone 2).

Historically, assessment rubrics, utilized by both instructors and sponsors, were employed to evaluate all three presentations. These grading rubrics included detailed information encompassing categories such as the Problem Identification, Project Needs and Requirement table, Design analysis, and component selection, Project Management and Cost estimation, Slide design and organization, Effective use of Visuals, Flow of information, Slide Design, and Presentation Style. Sponsors received a distinct rubric assessing both written and oral presentations. Students were explicitly informed about the criteria underpinning sponsor evaluations, including aspects like Understanding the problem, developing a Project Requirement Table aligned with client needs and constraints, Detail Design employing appropriate tools and methodologies, Meetings and correspondence with the Sponsor, and the Information and Data presented during the PDR and CDR. This holistic approach ensures comprehensive evaluation and aligns with the course's commitment to industry relevance and effective communication.

However, a noticeable gap emerged during PDR, CDR, and FDR presentation, where students often fell short in providing adequate information to elucidate their design or present a comprehensive picture of the project's progress and completed work. When prompted for self-reflection, students expressed confusion, having adhered to the rubric, yet finding their work quality not meeting the expectations of sponsors and instructors. The critical missing element was identified as the quality of the presented work and the overall narrative. Students, engrossed in checking rubric boxes and conforming to rigid categories, inadvertently neglected the crucial information transformation process and the art of effective storytelling.

The investigation unfolded in a two-part experiment within the initial phase of the senior design sequence. For the Preliminary Design Review (PDR), students were equipped with detailed rubrics delineating data presentation and slide deck design, establishing a foundational understanding of expectations. However, four weeks before the Critical Design Review (CDR), students were informed that they would not receive a grading rubric. They were granted the freedom to design their slides based on feedback from the PDR. Instructors clarified that grading would adhere to a rubric for standardization and fairness; however, given the pilot nature, students would receive detailed feedback, and leniency in grading to avoid grade anxiety.

To foster student learning, instructors conducted a workshop during a class meeting, engaging in a class discussion to collaboratively formulate a general rubric sourced from student input. Instructors moderated the discussion and established overarching criteria for presentation success. Each team was then tasked with refining a rubric tailored to their specific project scope, recognizing the diversity of projects within the cohorts. Students were encouraged to seek

feedback on a draft of their presentation slide deck during the subsequent week. This feedback process aimed at enhancing content quality, information flow, and visual effectiveness, with instructors adopting a facilitative approach, asking guided questions rather than directing students to predefined answers.

For the Critical Design Review, instructors informed sponsors that students hadn't received an official rubric, inviting sponsors to suggest improvements in data presentation, especially concerning industry norms. After the presentations and Q&A sessions, each team received detailed grading rubrics, ensuring transparency in assignment grading. Students were apprised that the Course Exit survey would feature three questions regarding the elimination of rubrics in a senior-level course, emphasizing anonymity to foster honest opinions without fear of retaliation.

The decision to eliminate the rubric and empower students to self-assess their presentation content and style stemmed from a significant factor—the prior workshop on Heilmeier Catechism during Capstone 1. In this workshop, student teams were tasked with crafting a single slide using the Heilmeier Catechism method tailored for an executive-level audience. This experience aimed to provide students with the chance to discern crucial data, emphasizing the importance of considering the audience's perspective during information presentation. The workshop played a pivotal role in instilling a high-level presentation approach, contributing to the instructors' confidence in entrusting students with the evaluation of their own presentations.

Results:

The fall 2023 semester accommodated three cohorts totaling 120 students in the senior capstone design course. As this course sequence is a graduation requirement, a case study was implemented to assess the students' receptiveness to the new methodology. Three questions were integrated into the existing anonymous Course Exit Survey to capture insights on:

1. *In the CDR presentation, the instruction team did not provide a rubric for slide design or the presentation. What aspect of this action was challenging for you?*
2. *In the CDR presentation, the instruction team did not provide a rubric for slide design or the presentation. Did you find this a valuable method for promoting critical thinking?*
3. *In the CDR presentation, the instruction team did not provide a rubric for slide design or the presentation. Did you receive questions from your sponsors during the presentation due to needing a rubric? Reflect on your experience.*

Additionally, students were prompted to self-reflect on their Capstone 1 experience and express their expectations for Capstone 2 to ensure a comprehensive understanding of their course experience and overall satisfaction.

Figure 1 illustrates students’ response to question 1. The response categories were chosen based on the nature of answers provided by students. Reported challenges in preparing for the CDR

presentation included the difficulty of determining the necessary information for slides and streamlining content for clarity was the major road block for students.

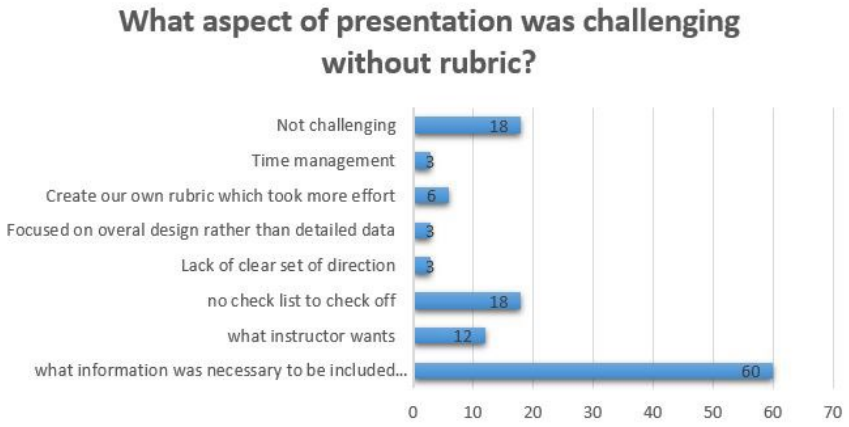

Figure 1: Students' response to aspects of the presentation that was challenging without rubric. N=120

Figure 2, shows students' response to question 2, the impact on critical thinking process. 90% of the students responded that the process was useful in "…forcing them to think harder about what needed to go into slides and provoked deeper thought process into the project..". Students reported they needed to focus more on what is important and highlight those topics. 2% of the students found this method to have negative impact on their critical thinking since they followed similar rubric from PDR. This group believes that the PDR rubric had enough criteria to help them with any presentation.

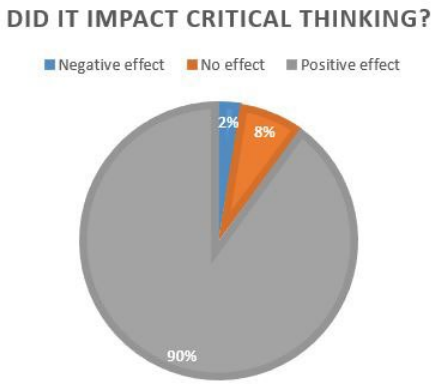

Figure 2: Students' response to the impact on critical thinking. N=120

Figure 3, reflects students responses to question related to interaction with the sponsor. 87% of the students reported positive or no impact on the amount of questions they received directly related the type of information they provided in the slide. However, 135 reported a negative impact and receiving criticism for "… not having parts [of the data] they have [sponsors] expected us to have on the slide even though there was no rubric." Most students mentioned they were able to answer sponsor questions but did not include the data.

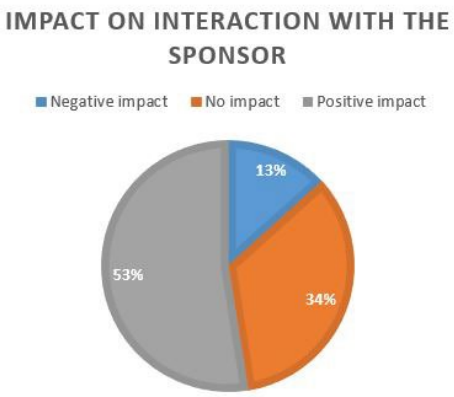

Figure 3: Students' response to impacts on interaction with the sponsor. N=120

Overall, students articulated that the absence of rubrics encouraged self-assessment, allowing them to take ownership of their learning journey and make informed decisions for improvement based on qualitative feedback from instructors and sponsors. The majority of students conveyed receiving insightful questions during presentations, offering valuable guidance for approaching future problems. Overall, students received positive feedback and praise for their presentations across the board.

At the outset of Capstone 2, the instructors presented the survey findings to the students, initiating a collective reflection on their journey. When posed with the question of whether they preferred a traditional rubric for the Final Design Review (concluding the capstone sequence), students unanimously opted for the free-form rubric, akin to the one employed in the Critical Design Review presentation. Their rationale centered on the belief that this approach not only fostered critical thinking but also granted them the autonomy to take charge of their work and craft their unique narrative. This ongoing research will persist, culminating in the collection of Likert-based data at the conclusion of the course sequence (Capstone 2), providing a comprehensive assessment of students' experiences with the empowering rubric.

Insights and Suggestions:

Maintaining a delicate balance between structured rubric guidance and the promotion of independent, creative thinking in senior design projects is paramount. Crafting rubrics that offer clarity on essential components while allowing space for interpretation and creativity empowers students to navigate innovative solutions within the rubric's framework. This approach provides the necessary structure for effective learning while fostering the independent and creative

thinking essential for success in the engineering field. To equip engineering students for self-assessment beyond the reliance on rubrics, the following strategies are proposed:

1. *Continuous Feedback Loop:* Establishing an ongoing feedback loop enables students to receive formative feedback throughout the project, promoting regular self-evaluation against predefined expectations. This mirrors real-world scenarios where continuous assessment and self-reflection drive professional growth.
2. *Professional Development Workshops:* Hosting workshops on professional development equips students with skills for self-assessment. Topics such as effective communication, project documentation, and presentation skills prepare students for workforce expectations, where self-evaluation plays a crucial role.
3. *Reflection Assignments:* Implementing reflection assignments at various project stages encourages students to assess progress, challenges faced, and lessons learned. These reflective exercises prompt critical thinking about individual performance, enhancing students' ability to self-evaluate without explicit rubrics.
4. *Peer Review and Collaboration:* Integrating peer review mechanisms encourages students to assess both their work and their peers', fostering a culture of constructive critique and self-reflection. This collaborative evaluation simulates dynamic interactions found in professional settings, enhancing communication skills essential for conveying project progress without explicit rubrics.

Conclusion:

In reflection, this exploration into the role of rubrics in senior-level engineering education has unearthed a critical dichotomy. While rubrics serve as invaluable tools for setting clear expectations, they can inadvertently stifle creativity and autonomous thought. As educators, particularly in senior-level courses, it is imperative to equip engineering students for the challenges of real-world scenarios where rubrics may not be readily available.

Acknowledging the value of rubrics in academia, there is an equal need to instill a deeper understanding of self-assessment. The emphasis should shift towards clearly defining learning objectives at the project's outset, ensuring students grasp the overarching goals and criteria for success. Rather than relying solely on rubrics, educators should empower students to align their work with these objectives, fostering a more intrinsic comprehension of what constitutes quality performance.

In essence, the key lies in fostering a culture of continuous improvement, feedback, and self-reflection throughout the academic journey. By incorporating these strategies into the curriculum, students can develop the skills required to evaluate their own performance effectively, even in the absence of rigid rubrics. This perspective aligns with the dynamic nature of the professional engineering landscape and provides a solid foundation for students to thrive in their future careers. This ongoing initiative introduced an empowering rubric to 120 senior

design capstone students. Qualitative assessments from the Course Exit Survey questionnaire unveiled students' receptiveness to this approach, enabling them to engage in independent thinking and articulate the project progress from their unique perspective.

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