

Are your rubrics hitting the mark? An exploration of the use of rubrics for project-based learning in engineering

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Abstract

Project-based learning is often introduced in engineering contexts to provide students with a better learning experience. Projects can be more authentic and can create opportunities for students to integrate knowledge and skills from several modules. Projects can also integrate an engineering curriculum with the simultaneous development and evaluation of technical and professional competencies. Furthermore, it is often argued that project-based assessments lead to deeper, more lifelong and self-directed learning. However, the assessment of work done during these projects presents many challenges. One of these challenges involves marking mechanisms. Project-based learning assessment frequently uses rubrics – designed to provide transparency regarding criteria used to evaluate students and consistency in the marking process. Sometimes, these rubrics can even be used as feedback to students. The questions arise, what makes a good rubric, and how should rubrics be designed to complement the intentions of project-based learning? This paper discusses findings from a qualitative study that explored lecturer and student experiences of assessment in an engineering school through interviews and focus groups. The study shows that the design of rubrics needs to be carefully considered to ensure that suitable types of learning are both encouraged and rewarded. Poorly constructed rubrics can result in dysfunctional student behaviours that do not support the intended learning outcomes of the assessment. This paper provides some practical recommendations that can be considered when setting up project-based learning assessments and designing assessment methods and rubrics to support these.

Keywords: Project-based learning; assessment; rubrics; student learning

1 Introduction

1.1 Background

In project-based learning, rubrics are often used as they are believed to be better suited to open-ended tasks that engage higher-order thinking (Jonsson & Svingby, 2007) and accreditation body outcomes and critical thinking (Newell, Dahm & Newell, 2002; Ralston & Bays, 2010). Furthermore, rubrics are often seen as a useful means to improve the efficiency of grading and providing feedback (Panadero & Jonsson, 2013). The purpose and function of rubrics vary, including clear expectations and transparency regarding the assessment and grading process, feedback, and self-evaluation skills. Regardless of the intention, rubrics are intricately woven into the grading or marks that students receive, and as a result, the power and influence that these rubrics have in the learning process are unquestionable (Boud, 2007). While rubrics can be carefully designed, how students respond is a function of how rubrics are perceived and engaged with (Lindberg-Sand & Olsson, 2008). If project-based learning is to affect the positive and sustainable change in student learning that is intended, a thorough understanding of what influences student assessment decision-making is required (Prosser & Trigwell, 1999).

1.2 Purpose of this study

The original study from which this paper draws its findings was designed to understand how assessment was designed and perceived by students in an Engineering School where student performance was significantly lower than desired. The larger triangulated study drew on student surveys (Hattingh, Dison & Woollacott, 2019), lecturer interviews (Hattingh & Dison, 2019) and student focus groups (Hattingh & Dison, 2021) to answer the following over-arching research question: How might current assessment practices be transformed to improve the quality of student learning in the School? The study adopts a theoretical lens that draws on learning-oriented assessment (Carless, 2015) and sustainable assessment (Boud, 2007). The intention is to

explore how student engagement, performance and success can be positively influenced by adapting assessment approaches that focus on the learning that is taking place and prepares students for their own future learning needs.

Many of the findings from the original study referred to rubrics, mainly used for projects, and how these were designed and used by lecturers and perceived and engaged with by students. The purpose of this paper is, therefore, to draw on the specific findings around rubrics to explore how rubric design can influence student learning and, through this, make recommendations for rubric design to support the overall learning intentions of project-based learning.

2 Literature review

2.1 Purpose of rubrics

Traditionally, the purpose of a rubric is to assign a level of performance or a grade (Goldberg, 2014) or "guide the analysis of the products or processes of students' efforts" (Moskal & Leydens, 2000). This is known as the summative purpose of a rubric. When used for a summative purpose, much focus is on the quality of assessment grading (Panadero & Jonsson, 2013), considering reliability and validity of the rubric itself, inter- and intra-rater reliability (Moskal & Leydens, 2000) or how accurately a score can reflect a student's abilities (Newell et al., 2002).

A formative approach to rubric use considers alignment with course objectives, clarifying expectations to students (Newell et al., 2002), and providing feedback (Catete, Snider & Barnes, 2016). Rubrics can also be used to provide a quick overview of student progress (Ralston & Bays, 2010) which can be used to adapt the learning environment.

Rubrics, if effectively designed, can be used both summatively and formatively (Stegeman, Barendsen & Smetsers, 2016). They should articulate expectations for an assessment task and typically do this through criteria and descriptions of levels of quality in relation to each criterion (Reddy & Andrade, 2010). Rubrics in more design or project-oriented contexts can include criteria that consider design process elements such as problem definition and feasibility, product-oriented criteria such as user experience and professional competencies such as teamwork and entrepreneurship (Huang & Jong, 2020).

2.2 Impact of rubrics on student learning

Rubrics can positively influence student learning in several ways. Rubrics are a mechanism to make assessment criteria explicit which provides transparency to students, but it also requires lecturers to reflect on these criteria when setting up assessment tasks. In this way, rubrics can facilitate constructive alignment (Biggs, 1996) of assessment design which supports improved student learning. Rubrics can increase transparency, reduce anxiety and provide feedback to students (Panadero & Jonsson, 2013). For this feedback to be valuable, students need to identify what good performance is, how their own performance relates to this and how they can go about closing the gap (Stegeman et al., 2016), promoting sustainable assessment practices (Boud & Soler, 2016). All of this supports the development of self-regulation skills and self-efficacy (Panadero & Jonsson, 2013). Rubrics are further able to support self-assessment (Andrade & Valcheva, 1999) and related activities such as peer evaluation (Mullen, 2003) which can support the development of lifelong or sustainable learning skills (Boud & Soler, 2016).

2.3 Challenges of rubrics

There are, however, many challenges with rubric design. Some of these stem from rubrics that are not well designed or designed with a predominantly summative focus. Others originate from a lecturer-focused approach that does not consider how students will engage with and respond to the rubrics and the impact that this will have on their overall learning experience.

The criteria of many rubrics focus on the product or artefact that is being assessed (Catete et al., 2016; Verleger, Rodgers & Diefes-Dux, 2016), which can mean that there is limited consideration, visibility or evaluation of the

process that is taking place and the assessment task remains product-centred (Gibbs, 1995). While it is often easier to grade or evaluate something tangible such as a design or a design report, it is the process that students will take with them into the working world. If rubrics are to be used to provide formative feedback to students, the criteria and descriptors also need to provide guidance on how the process that leads to the artefact can be improved in the future. If rubrics are to be used to develop self-evaluation capacity, students need this visibility to judge their approaches.

Criteria in rubrics often include scale descriptors such as adequate, reasonable or poor (Huang & Jong, 2020), clear, accurate, complete and fair (Ralston & Bays, 2010) or few, some, most, all, slightly, moderately, mainly and extremely (Tierney & Simon, 2004). While these may enable raters to be more consistent and reliable, one may question how useful these descriptors are to a student and whether they enable valuable feedback that students can engage with and improve. While a grader may be able to develop a sense of what complete or reasonable is, students need to develop these skills. In some cases, examples can be included in the descriptors, often to improve reliability and validity or grading, but also to try and provide better guidance to students. Depending on student dispositions and intentions when using the rubric, this can tempt students to adopt procedural or tick-boxing approaches, defeating the rubric's objective to develop self-evaluation skills.

Whenever using rubrics, it remains key to consider how the students will perceive and use the rubrics during the design process. By providing clear expectations and criteria, rubrics provide a very structured framework that students can use when tackling assessment tasks. Some would argue that students could become dependent on these rubrics. The clear guidelines could lead students to avoid a trial-and-error approach to their problem-solving processes (Panadero & Jonsson, 2013), following a more mechanistic procedural-learning approach (Case & Marshall, 2004). This does mean that rubrics can encourage instrumentalism or assessment as learning where criteria-compliance dominates the learning process (Torrance, 2007), which works against the idea of project-based and sustainable assessment practices.

2.4 Opportunities for consideration

The value of rubrics often remains centred on the robustness and inter or intra-rater reliability. Rubric design principles tend to speak to inconsistencies and redundancy in descriptors, unevenness in increments and limited routes to partial credit (Goldberg, 2014), language, terminology and phrasing (Stegeman et al., 2016) and frequency and intensity of descriptor levels (Tierney & Simon, 2004). Even when rubrics are designed to provide feedback, analysis of the rubric often remains focused on reliability and validity and how the feedback is perceived and used by students is not evaluated (Catete et al., 2016; Stegeman et al., 2016). While sophisticated rubrics provide a structure that can be used to provide a holistic and accurate evaluation that extends beyond the product or artefact to critical thinking (Ralston & Bays, 2010), very rarely do the studies discuss how the rubrics are perceived or used by students.

Panadero & Jonsson (2013) conducted a review of literature that explores the impact of rubrics on student learning. Their findings revealed that most research remains focused on the summative aspect of rubrics and limited studies consider the formative impact of rubrics. For those studies that do look at the formative aspect, few have been conclusive as case studies that use rubrics formatively typically combine rubric use with other meta-cognitive activities such as peer-evaluation.

While the value and importance of the summative aspect of rubrics are acknowledged, their influence on student learning behaviours and, ultimately, student learning cannot be ignored. Learning-oriented and sustainable assessment thinking requires that the primary purpose of any assessment activity is the support of student learning and the development of self-judgement and evaluation skills. Since rubrics form an integral part of this process in project-based learning, it is imperative to understand how rubrics can be designed to support this.

3 Method

3.1 Study context

This study takes place at an engineering school ('the School') in a South African university. Assignments (or projects), tests, and exams are the primary means of assessing student performance. Larger projects are used in various courses but mainly in design courses and can be conducted individually or in groups. Although the predominant means of assessing remains tests and exams, there has been a distinct shift toward the use of projects. Projects can contribute significantly to the overall course mark in practical and design courses.

3.2 Research approach

The findings presented in this paper draw from two parts of a larger triangulated case study. The original study consisted of a student survey, lecturer interviews and student focus groups to obtain a holistic view of assessment practices and how these influence student learning behaviours. The study used a qualitative exploratory approach to draw on individual and group experiences. This paper will draw specifically on findings from the lecturer interviews and student focus groups. The study aims to understand the decision-making and intentions of lecturers when designing and using rubrics and the students' experiences and intentions when tackling assessment tasks that use rubrics. The study does not focus on a particular module but considers students' holistic approach to assessment tasks since the orientation of a student towards assessment is influenced by their prior learning experiences (Biggs & Tang, 2011) and what happens in a particular course and around it (Boud & Soler, 2016).

3.3 Lecturer interviews data collection

Semi-structured, individual interviews were conducted with ten purposively sampled lecturers in the School. Lecturers were posed with a series of open-ended questions designed to explore their perceptions and experiences of the overall purpose of assessment. These included factors that influence the design of assessment tasks; explicit and implicit criteria used to design and evaluate tasks; communication of expectations and criteria to students, feedback, experiences of student engagement with tasks, how well assessments evaluate the intended outcomes and how assessment could be improved. The interviewed lecturers teach a range of courses across all four years of study, including mechanics, engineering drawing, mechatronics, engineering design and laboratory courses and complementary courses such as business management.

3.4 Student focus groups data collection

Focus groups were conducted using a protocol that encouraged students to reflect on both their own experiences and, where necessary, to comment on what other students might experience or do (Merriam, 2009). The questions probed several issues, including students' overall approach to their studies in respect of different assessment tasks; how they knew what was expected from them in assessments; an example of a situation in which they were disappointed by an assessment, and how they reflected on this experience; forms of received feedback, and their response to feedback. Students were asked to reflect individually by writing down their thoughts on selected questions before engaging in the group discussion, allowing them to formulate their thoughts before being influenced by others (Gibbs, 2007). The focus groups were facilitated by the researcher and observed by a research assistant. The sessions were recorded and later transcribed.

The focus groups sampled all students in the School from the second, third, and final years of study. Four separate groups of students were chosen for the focus groups using maximum variation sampling (Cohen, Manion & Morrison, 2011): a mid-performing group (FG1), a high-performing group (FG2), a low-performing group (FG3) and a group of students categorized as turnaround students (FG4). The turnaround students performed exceptionally poorly in one year, followed by a year when they performed particularly well. Emails were sent to students from all groups, inviting them to be part of the focus group on a specified day. The number of emails sent out was increased until five to ten students (Merriam, 2009; Cresswell, 2012) consented to be part of each focus group. A total of 22 students participated in the focus groups.

3.5 Data Analysis

Recordings of the interviews and focus groups were transcribed and analysed. Focus group analysis included individual voices, and the sense-making that emerged as a shared understanding was developed in the group (Cresswell, 2012; Wilkinson, 2004). The original study tracked emerging concepts using a coding system linked to key supporting quotes (or evidence). This process was repeated for each transcript, comparing and adding codes when required. The identified codes and evidence were then captured into a case study database (Yin, 2014). A comparative analysis was then carried out, clustered into topical categories informed by the literature (Merriam, 2009) until a set of emergent themes was obtained. To address the credibility of the findings, rich descriptions and evidence were used to support the claims. Surprising or 'outlying' evidence was investigated, and rival explanations were considered when interpreting data by referring to literature and using peer review with two colleagues (Cohen et al., 2011; Merriam, 2009). For this paper, themes and codes that linked specifically to the topic of rubrics were extracted and are discussed herein.

4 Findings and discussion

4.1 Introduction to the findings

Although there are indications that assessment is sometimes used as a learning opportunity, the predominant thinking in the School is assessment of learning, to evaluate the competence of students. This thinking frames most decisions that lecturers make when designing and using assessments. Lecturers aim to discourage the use of rote learning strategies and attempt to test if students have a deep understanding of concepts by requiring students to apply their knowledge and understanding of concepts to new and unseen problems, often using real-world scenarios. Students indicate a preference for projects as they enable them to better understand concepts and are more relevant to the real world and the engineering profession. Student learning behaviours in the School are, however, dominated by a studying for passing paradigm where students strategically make decisions that will enable them to pass or obtain as many marks as possible, often at the expense of learning. Within this context, findings of particular interest to the topic of rubrics are discussed. The quotations are referenced back to the data source, i.e., L1 representing lecturer 1 and FG1 representing focus group 1.

4.2 Product or output-focused nature

Lecturers describe an underlying set of skills that students are expected to exhibit. These align with the process of problem-solving and include: to understand and visualise complex problems, to source and understand relevant information, to apply appropriate concepts to analyse/solve complex problems, to integrate the problem into related systems and to communicate ideas. However, many lecturers describe the criteria used to evaluate students in terms of the specific requirements that the product that was being designed needed to meet or sections of a report rather than the outcomes that the student needed to demonstrate to be able to design the product so that the product met the requirements. Rubrics reflect this and are often designed in a way that provides criteria simply as mark allocations for each section of a report or task. Gibbs (1995) warns against using rubrics in a way that does not provide any indication of the quality of work that is required to achieve the marks that are allocated for a particular section. Furthermore, as the assessment criteria are product-oriented, they understate what students need to achieve and provide minimal scaffolding for students to appreciate the concept of quality in their work (Sadler, 2010). Feedback also typically focuses on the product of the assessment task, indicating how the answer or design has not met the engineering specifications or requirements without suggesting what the student could have done differently to improve the quality of their engagement with the task to deliver a quality final product. The feedback is, therefore typically aligned to "what" needs to be improved, a focus on the diagnostic element, and not the "how" of getting there, the bridging-the-gap element (Boud & Molloy, 2013). This simplistic view of criteria used in the rubrics disregards the process of learning and engagement, which affects feedback and student use of rubrics, including the development of judging capabilities and self-evaluative expertise (Carless, 2015).

The breaking down of criteria into discrete elements or steps is perceived to ensure consistency and objectivity in marking. However, the criteria that assess quality or understanding underpinning the steps become much more difficult for lecturers to explain. Some lecturers admit that they find it difficult to explain to students what is required of them to perform well:

"Students often ask: ...how can I pass this course? And even though I get asked this a lot of times, I always struggle to answer it....have you understood and can your design, do what it needs to do?" (L9)

This inability of some lecturers to explain to students **how** to improve could stem from a lack of awareness of the importance of threshold or bottleneck concepts and their role in unlocking understanding and the construction of knowledge and ideas (Middendorf & Pace, 2004). As a result, rubric criteria and therefore, feedback does not articulate to students what they need to demonstrate to meet the required outcomes, which further hampers the development of self-evaluative skills.

4.3 Tick-boxing and instrumentalism

To facilitate a shift to learning-oriented and sustainable assessment, attempts need to be made to develop students' capacity to self-evaluate. This can be done in several ways, but improving the communication of expectations and criteria to students is a key priority. However, as students are already operating in a studying for passing paradigm, there is a risk that increasing the transparency of outcomes and criteria could lead to an over-reliance on these with criteria compliance (Torrance, 2007) replacing learning. As the content of rubrics remains product rather than process-centred, this can lead students to use the rubrics as a means of cue-seeking and mark-hunting, resulting in mechanistic and "tick-boxing" strategies. This lecturer reflects:

"So I almost think that the very detailed rubric can be a disadvantage. Because they're just trying to tick boxes at the end of the day." (L1)

Although assignments and projects are seen as a better way of encouraging students to develop the necessary process-type skills, the use of rubrics in this School is potentially encouraging students to go through the breakdown, ticking off steps in a procedural manner in order to "get marks". This is certainly exacerbated by the already existing student focus on marks in the School, where students appear to prioritise and focus their attention based on the marks that are provided for all assessment tasks:

"that's why the interactions that you end up kind of having with the lecturers are okay, why are my marks so low...it's not okay, help me understand this concept, it's my mark needs to advance...so at the end of the day, it's all about marks." (FG2)

Students particularly do not see value in feedback for an assignment if they are not going to get something similar again since the rubric is only used to "tick boxes" against mark allocations rather than change learning behaviours and approaches to solving problems that are universally useful in future learning.

"Like also in the rubric, it's not always helpful, because some of the lecturers only give it to you when (you've already done the work) and that doesn't help you because then you're kind of just doing whatever and when you get the rubric you might have to add something in or take out or stuff. So if they give it to you beforehand you then know like how to use your time." (FG1)

"I think getting a rubric also helps. Especially if there'll be a follow or similar type thing, then you can see exactly where the marks are, where you need to improve." (FG2)

The product-centred structure of rubrics and tick-boxing approach of students can also lead to mechanistic or boxing approaches to tackling assignments:

"...the students have a mechanistic approach ...{without} the subtleties as to why you should be doing this or that." (L8)

This can also be amplified by group projects:

"Students end up splitting parts of a report (between group members). And this is a problem, not only because you're not actually practising but also because then you're not realising what the link is between everything. And if you're having to do the entire project that becomes an entirely different story." (L7)

The adoption of mechanistic approaches implies a lack of underlying problem-solving skills and strategies and the development of skills that can integrate elements. This can exist between aspects of an assignment, sections of reports, problems and surrounding systems and how courses and the degree links together as a whole.

4.4 Agency and self-evaluation

Findings from this study reveal that students are not necessarily developing self-evaluative skills and do not adopt agency for their own learning. There is a sense that the agency for learning and assessing lies with lecturers, impeding the ability of students to develop their technical and professional competencies. Students' ability to self-evaluate and improve is limited by the current product-centred nature of rubrics which do not enable students to see where they are going wrong or develop ways of reflecting, changing and improving. The following participant sums up this frustration:

"You work really hard on your assignment and you get it back and you realise you've gone wrong, and it gets you really down because you spent so much time doing it and it doesn't show you what's wrong." (FG1)

This quote also hints at a lack of agency. It appears that students expect lecturers to "tell them what is wrong" rather than developing the ability to self-evaluate where they went wrong.

"...lecturers should sit and see where most students are going wrong and try to come to class and work out some of those mistakes that students make." (FG1)

This is confirmed by lecturers who also discuss their frustrations:

"That is the number one question students always ask is what are you expecting? Where's the rubric? Is this right?...Their biggest question is, how will I be assessed? Is this work good enough? Have I done enough?" (L4)

The development of self-evaluative skills is a crucial aspect of sustainable assessment and project-based learning. However, the assessment context needs to provide structure and support for students to identify with, adopt and exercise agency to create opportunities for developing these skills (Ritchie, 2016).

5 Conclusion

The findings show that rubrics can indeed influence student learning behaviours. Furthermore, they show that they can have a negative impact on the competencies that project-based learning aims to develop. As a result, rubrics should be intentionally and carefully designed, and the perception and response of students should be investigated. Practically, rubrics should incorporate criteria and descriptors that are process-centred and encourage students to integrate their learning in other projects and courses to develop sustainable, lifelong learning skills. They should provide sufficient guidance for students to develop self-judgement skills without becoming over-reliant. It is also recommended that the use of rubrics includes supplementary meta-cognitive activities that transfer agency and scaffold the development of relevant skills. This requires lecturers to think beyond the reliability and validity of rubrics, considering the student learning process, threshold concepts and constructive alignment.

6 References

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