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Learning strategy regulation processes with rubrics for learning assessment

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ABSTRACT
Learning assessment can be done with the help of the development of rubrics. Rubrics are used to evaluate a wide variety of aspects of the pedagogical process; they are even very efficient for standardizing assessment and creating feedback. The adoption of rubrics helps establish educationally appropriate criteria and performance levels for both metrics and performance measurements, including complex learning structures such as the pedagogical framework. Regulated learning frameworks has come to be cornerstone for examining learning forms of regulation. Despite recent advances in the area of self-regulated and co-regulation, more research is still needed on how groups of students regulate their learning in learning environments in the classroom context. In this work we apply, we re-designed Pintrich's self-regulation framework, placing a special emphasis on the crucial role of performance measurement in learning with the aid of rubrics, providing a more holistic view of regulatory processes. The extended framework presented here has implications for practice, being especially beneficial in creating strategies for facilitating students' self-regulation and co-regulation. This study provides valuable information for educators regarding instructional design and the selection of appropriate regulatory processes to shape and measure learning activities within a framework. It was developed a complete prototype called the Learning Assessment System by Rubrics.

Keywords: Rubrics, Self-regulation, Learning assessment.

INTRODUCTION

Learning regulation refers to the process through which individuals manage and control their own learning activities, strategies, and behaviors to achieve desired learning outcomes. This ability involves the ability of students to use their mental resources to perform educational tasks, such as acquiring knowledge about the task and establishing the necessary strategies for its execution (Ferreira et. al. 2024).

One of the most efficient ways to systematically assess learning regulation is to use assessment tools such as rubrics. Rubrics are excellent for measuring indicators for evaluating learning.

Rubric is generally a document that contains a list of assessment criteria, a scoring strategy, and definitions for measuring a given objective for performance measurement. It is a very efficient and useful tool for both evaluations and feedback (Steve and Levi, 2013; Wollenschläger et. al., 2016).

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Rubrics are important for measuring multifaceted aspects of learning, from typical pedagogical activities in the classroom to complex learning frameworks. Research indicates that the use of rubrics in assessments encourages self-regulated learning (Habib et. al., 2021) and co-regulation (Fraile et al. 2017).

To achieve success in mastering both individual and group tasks, students can engage in efficient control mechanisms to regulate their thinking, actions, feelings, and surroundings. Therefore, individuals need to not only self-regulate, but also guide and support the regulation of others in the group and regulate together as a collective system. They need to be cognitively and socially present to attain the learning goals. It another way, they can be able to communicate openly and contribute to group cohesion and motivation, constructing meaning in a discursive and reflexive way. (Garrison and Arbaugh, 2007).

It is not a simple task for students to regulate learning by themselves, especially when activities are computer-mediated (Durmaz, 2020), so aid in this type of regulation can be useful to students. However, the students can learn how to regulate themselves as individuals, and as a learning group, the student capacity for regulation can be developed through observing and emulating regulatory processes (MacMahon et al., 2020).

With the aid of rubrics, it is possible for the teacher to apply a set of strategies to facilitate the student's self and co-regulation. It is possible to use the criteria and dimensions of the rubric to measure these strategies and skills students in a standardized and systematic way, according to the pedagogical objectives defined by the subject's faculty.

The Pintrich's framework is the most complete self-regulation framework in the literature (Pintrich, 2000).

Aiming for an integrated, cohesive, and comprehensive view of regulatory processes in measurement learning activities, addressing both self-regulation and co-regulation, we developed a prototype using the Web framework and the MTV Design Pattern to implement standards rubrics. This prototype for the development of rubrics for an expansion of the Pintrich's framework (Pintrich, 2000) for undergraduates.

Standards rubrics definitions describe what students need to take into account to demonstrate a particular level of performance in accordance with the teaching objective (Reddy and Andrade, 2010).

LITERATURE REVIEW

Learning Assessment can be done with the help of the development of rubrics in science education through educational topic modeling techniques (Hong and You, 2024). Recent research in collaborative learning have extended theories and models of self-regulation to collaborative learning situations where shared knowledge construction is underneath. Self-regulated learning frameworks has come to be cornerstone for examining social forms of regulation (Hadwin et al., 2018).

Despite recent advances in the area of co-regulation, more research is still needed on how groups of students regulate their learning in collaborative environments (Lobczowski et al., 2020). In this paper, Pintrich's (Pintrich, 2000) self-regulation framework is used as a pillar for the generation of a framework that encompasses both self-regulation and co-regulation learning processes.

Andrade and Brookhart (2020) expanded Pintrich's model (Pintrich, 2000) in its phases and areas of self-regulation of learning to include regulation by others, where the learning regulation is led by an individual group member.

In addition, the authors use teacher assessment in the classroom as a parameter for the co-regulation of learning. In the elaboration of the Framework developed in this research, we used the theoretical assumptions of the collaborative learning area supported by the computer. In collaborative learning supported by the computer, all students are responsible for advancing knowledge or to achieve the solution of a problem or task, the group’s goals and strategies are negotiated and shared by the group. Thus, although Andrade and Brookhart (2020), address all phases of Pintrich's model (Pintrich, 2000), their approach differs radically from ours with respect to the theoretical perspective.

Lobczowski et al. (2020), proposes a co-regulation model with a focus on the emotional aspect of students. This author uses ideas from traditional, social, developmental, and educational psychology, combining key elements of seminal theoretical models to present a new model of formation and regulation of emotions in collaborative learning environments. Again, this model differs from ours, since our proposal includes, in addition to the emotional dimension, the socio-cognitive, behavioral and contextual dimensions.

As in the work of Andrade and Brookhart (2020), this research is based on teacher evaluation processes, therefore it differs from the framework proposed in this work that addresses processes that lead to successful student collaboration, that is, where students build knowledge together.

The study by Hwang et al., (2021), adopted an online learning approach based on social regulation to help students self-regulate to achieve mathematical learning goals with the help of their peers. In this study, an online learning structure based on social regulation is proposed to deal with this problem of self-regulation in mathematics. It is expected that, when referring to the self-regulated students' learning strategies, the lower self-regulated students will learn how to make and achieve their own study plans and, therefore, improve their learning outcomes. The authors argue that it is imperative to understand and record student behaviors in student-centered and problem based learning. Students 'learning behaviour patterns can be a reference for researchers and teachers to examine factors that affect students' learning outcomes, as well as to develop more effective learning strategies (Hwang et al., 2021). And the approach differs from the approach proposed in this research, as it is limited to social aspects in favor of self-regulation, leaving aside group regulation processes, such as co-regulation processes to determine a common objective and strategies for collaboration.

Svana (2024) says that new programmers need help to do well in their classes. This assistance necessitates the possession of both pedagogical content knowledge and general pedagogical knowledge. A rubric to evaluate the quality of experiment. She discusses the theoretical foundation for the rubric, the entire rubric, and two evaluation strategies. First, she used the rubric to evaluate 85 written answers from students. Second, the rubrics were evaluated by experts and looked at their opinions using qualitative analysis. The research revealed positive aspects, aspects that could be improved, and other areas of application such as support for reflection on the use of rubrics to assess novice students.

The effects of different levels of student regulation support on the learning process and outcome were investigated by Radović et. al. (2024). Regulated learning involves an iterative process, where students take an active role in evaluating their own work using appropriate criteria and rubrics. As a result, in their research, the rubric criteria and dimensions were used and planned to evaluate regulated learning quality indicators.

METHODOLOGY

The first step of the methodology is to define the framework for learning strategy regulation processes with the aid of rubrics. This paper was adopted Gibbons and Bunderson' method (Gibbons and Bunderson, 2005) for the elaboration of the regulatory process framework, see Table 1.

Table 1. Features of Gibbons and Bundersons' method (Gibbons and Bunderson, 2005)

Explore	Answers "What is there?". Defines. Categorizes
Explain	Answers "Why does it happen?". Search for causality and correlation. Works with variables and relationships between them

Table 1 shows how exploratory and integrative models are used to define and group groups and relationships. This helps explain and understand the processes involved in learning approaches.

In this paper, we approached exploring and explaining phases (table 1) by means of a content analysis of the literature (section 2) having in mind Pintrich's main categories. Exploratory research seeks to explain why and how. It defines and categorizes, identifying what exists and the possible groupings and relationships between what exists.

The model of Pintrich involves the metacognitive control of individuals over their cognitive, affective, motivational, and behavioural states when planning, monitoring, evaluating, and adapting learning; however, it is limited to the individual context. In other words, it does not include the regulation of students in collaborative groups.

The contextualization and adaptation of the Pintrich's Framework, which contains regulatory processes, are done in four phases.

Building a rubric involves a systematic approach to define the criteria and performance levels that will be used to assess a particular task or set of tasks.

In this paper we use the methodological strategy of creating a "metarubric" to validate the reliability, validity, and transparency of the rubric. A “metarubric” is a rubric used to evaluate rubrics. Rubric feedback and assessment are greatly facilitated with the application of a "metarubric” as it allows listing the assessment criteria by describing levels of quality in relation to each of these criteria in a standardized way.

“Metarubrics”, like teacher evaluations of assignments, are for our own research use and tend to be contextualized to the research itself. Checklists are easier and quicker to use. When we use the “metarubric”, we glance back and forth from the rubric to the “metarubric” criteria. It helps refine and polish some details in the rubric (Steve and Levi, 2013).

The methodology used to build a tool capable of aiding in the construction of rubrics with different pedagogical objectives was prototyping. Prototypes provide a tangible representation of abstract ideas. They allow to visualize the product early in the development process. This helps in clarifying requirements and expectations.

The prototype was made using design patterns. The prototype was developed with the MVT (Model-Template-View) architectural design pattern, which is the design pattern under which the Django Web Framework was built.

CONTEXTUALIZATION AND ADAPTATION OF THE PINTRICH'S FRAMEWORK FOR RUBRICS

The processes, is done in four phases. This framework was contextualized and adapted for introductory programming learning. This paper has been re-adapted by us to be used for rubrics in the context of CSE (Computer Science Education).

Each phase contains four sub-dimensions of the rubrics responsible for dividing the areas for social regulation for contextualization and adaptation of Pintrich's Framework. The sub-dimensions are: socio-cognitive, socio-emotional, socio-behavioural, and socio-contextual.

Phase 1 refers to forecasting, planning and activation. The criteria and dimensions of the rubric must be planned before applying it to a specific teaching activity. The sub-dimensions of these phases are:

- Socio-cognitive: Establishes understandings of shared demands and individual tasks, negotiates the meaning of the problem, and sets goals. Establishing an understanding of the concepts of theory or programming learning.
- Socio-emotional: Anticipates good relations when the task is done in a group. Encouraging future participation and interactions. Good moods and motivational phrases are used in the activity.
- Socio-behavioural: Creating from streams, work to achieve goals, including the definition of schedule. Negotiating the division of work when done in a group. Using Scrum to plan collaborative programming tasks when they exist. Scrum is a management framework that teams use to self-organize and work towards a common goal.
- Socio-contextual: Negotiate and describe roles according to the profile of the student or group. Organizing the team (protocol of communication/rules of engagement). If the task is in a group, choose groupware technologies for programming. Planning a collaborative program writing.

Phase 2 refers to monitoring pedagogical activity. If the activity involves programming, it includes monitoring during coding and testing. The sub-dimensions of these phases are:

- Socio-cognitive: Monitoring understanding of the task, including shared understanding. Monitoring the processes in general. Accompanying the advancement of knowledge. Detecting errors and verifying their plausibility. Detecting socio-cognitive conflicts, if done in groups and involving programming, requires understanding the patterns and structures used. Monitoring the resolution of collaborative programming problems when done in groups.
- Socio-emotional: Monitoring one's own motivation or a group's motivation for participation and interactions. Detecting socio-emotional conflicts in the group. Monitoring group commitment to tasks.
- Socio-behavioural: Tracking individual or group goals and progress. Using workflows to monitor the progress of activities. Using Scrum to monitor tasks of collaborative programming if they exist.
- Socio-contextual: Monitoring changing roles and communication protocols between student and teacher or between students. Monitoring the rules of engagement. Monitoring

the context of collaborative programming if the activation involves programming and is in a group.

Phase 3 refers to control of the activity, including coding and testing if it involves programming. The sub-dimensions of these phases are:

- Socio-cognitive: Discovering the type of collaboration or interaction needed to solve the problem, along with the objectives. Subdividing the theoretical or computational problem. Analysing and building software artifacts from others in the case of reuse.
- Socio-emotional: Controlling the quantity of the work itself, if done in a group, means controlling participation and interactions. Avoiding and controlling socio-emotional conflicts with the teacher or the group. Promoting respect during criticism of the other's standpoint by the teacher or group. Promoting participation in programming. Developing trust relationships in programming and, if necessary, providing feedback on group participations and interactions or to the teacher.
- Socio-behavioural: Managing workflows. For instance, using Coding DOJO (Kata), using Coding DOJO (Randori) in programming. If done in a group, seeking teacher help when students cannot reach consensus on a conflict of ideas.
- Socio-contextual: Controlling roles in interaction with the teacher or other students with communication protocols. If necessary, provide feedback on group roles and communication protocols. Analysing the pros and cons of programming. Working in the context of collaborative programming if the task is done in a group.

Phase 4 refers to the reaction and reflection of pedagogical activity. The sub-dimensions of these phases are:

- Socio-cognitive: Reflecting on goals, progress, and achievements. Making adaptations to goals, plans, or strategies. Reflecting on alternative solutions to computational or theoretical problems. Reflecting and repairing shared understanding with the teacher and other students.
- Socio-emotional: Reflecting on task motivation. Reflecting on trusts in programming. Evaluating the emotional aspects of the student, teacher, or group members regarding mutual respect and engagement in group activities. Evaluation regarding the number of interactions and how different people interacted, including the teacher. If done in group evaluations regarding the number of interactions and how many people interacted, it would prevent a lack of participation and poor interactions.

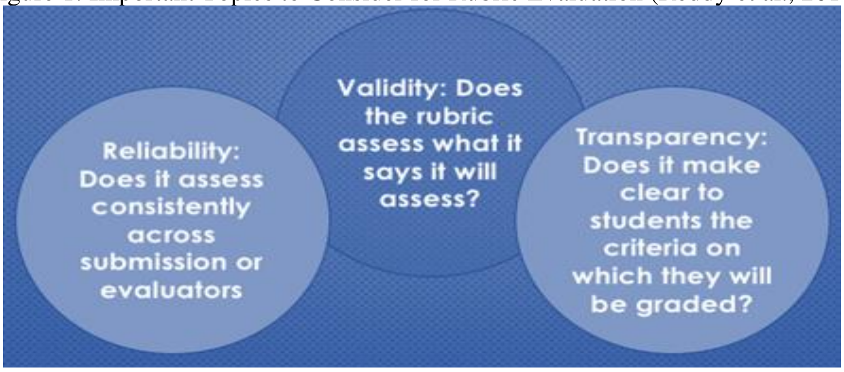
- Socio-behavioural: Reflecting on goals and progress. Reflecting on workflows to check productivity. Adapting workflows. Reflecting on the pros and cons of Scrum when using collaborative programming.
- Socio-contextual: Reflecting communication protocols with the teacher or with the group if the task is done in a group, adapting group functions and communication protocols. Reflecting on the context of collaborative programming, if applicable.

RELIABILITY ASSESSMENT METHOD BY "METARUBRICS"

According to Reddy and Andrade (2010), reliability refers to the consistency of scores that are assigned by at least two independent raters (inter-rater reliability) and by the same rater at different points moments (intra-rater reliability).

Analysing the literature, three important topics are most frequently cited by researchers for rubric evaluation: reliability, validity, and transparency. Figure 1 shows that there is a relationship between them. Reliability allows us to assess consistency across the submission itself or between evaluators. Validity allows us to infer whether the rubric really assesses what it says it will assess. Transparency allows us to clarify to students the criteria on which they will be graded.

Figure 1: Important Topics to Consider for Rubric Evaluation (Reddy et al., 2010)



Rubrics are flexible, adaptable grading tools that become better and better the more times we use them. Their strength, reliability, and validity increase as we use rubrics, discover limitations, and make revisions. But to make effective revisions, we first need to evaluate our existing rubrics. In this paper, we will use "metarubrics".

"Metarubrics" must be evaluated by teachers who know how to evaluate and define well the criteria and dimensions of the rubric for a given pedagogical activity in accordance with the learning objectives. Validation of a "metarubric" is done by experts who answered the following Yes/No questions the Figure 2.

Figure 2: How to evaluate the overall quality of your rubric. The Template described in (Stevens and Levi, 2013) and contextualization and adaptation by us.

Rubric Part	Evaluation Criteria	Yes/No
The Criteria and Dimension	*	
The Descriptions	*	
The Scale	*	
The Overall Rubric	*	
Fairness or Sensibility	*	

The evaluation criteria (Figure 2) are contextualization and adaptation by us from the literature, and the three main parts of each rubric parts, in our opinion, are:

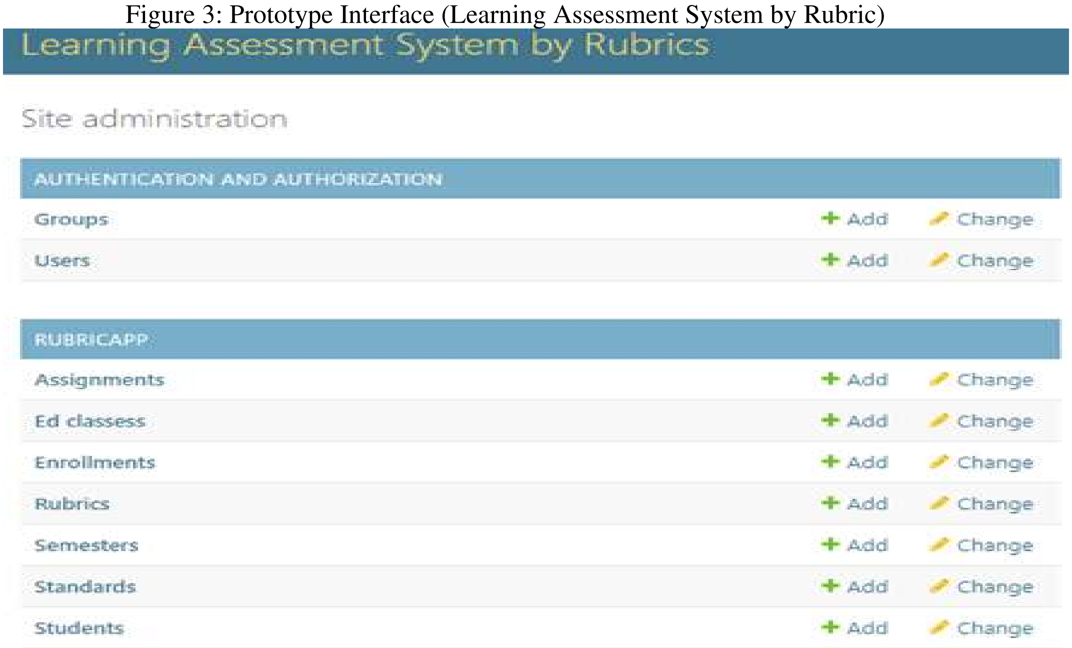
- Criteria and dimension:
  - Do you think there is a dimension are necessary and sufficient for the pedagogical activity?
  - Did you think there was any overlap between the criteria? Were there criteria that was difficult to use?
- Descriptions:
  - Do you think the descriptors included in the rubric were enough to assess each criterion?
  - Did you think hat the descriptors were clear enough? Do your descriptions match the criteria?).
  - The scale (Are the labels on the scale encouraging and informative without being negative and discouraging?
  - Do the descriptors under each of the criteria truly represent that there is a well-defined level of performance?
  - Does the rubric have a reasonable number of criteria for the level of the student and the complexity of the assignment?
- Overall Rubric:
  - Do you think this “metarubric” could be used as a basis to assess students in pedagogical activities?
  - Do you think students would understand the rubric?
  - Have all students had an equal opportunity to learn the context and skills necessary to be successful in the pedagogical activity?
- Fairness or Sensibility:
  - Does the rubric look like it will be useful to students as learning feedback?
  - Is the rubric appropriate for the type of assignment?
  - Does it look like the rubric will be fair to all students and free of idiosyncrasy?

Obviously, if some evaluation criteria are negative, it is necessary to redo the rubric criteria so that they are satisfactory.

FRAMEWORK PROTOTYPING BY RUBRICS

The complete prototype was called by us Learning Assessment System by Rubrics. It was built using a web framework for development using the Python language called Django and the PostgreSQL database. The main interface of the Application that manages rubric manipulation can be seen in Figure 3.

Figure 3: Prototype Interface (Learning Assessment System by Rubric)



DESCRIPTION OF THE PROTOTYPE’S MAIN FEATURES

Rubrics are composed of four basic parts in which the teachers set out the parameters of the academic activity assessed. The parties and processes involved in making a rubric can and should vary tremendously, but the basic format remains the same.

In its simplest form, the rubric includes a task description (the assignment), a scale of some sort (levels of achievement), the dimensions of the assignment (a breakdown of the skills/knowledge involved in the assignment), and descriptions of what constitutes each level of performance (specific feedback) all set out on a grid.

The tool's interface allows the construction of different types of rubrics and their reuse and adaptation to the pedagogical needs of a specific task or discipline or learning methodology. Which is essential for adoption of the tool by researchers or teachers. It is important to emphasize that the prototype was developed with free software established in academia and the software industry, so that the adoption of the prototype will not generate an economic burden in its adoption.

The prototype is divided into two components or two applications (App) according to Figure 3.

- The first component refers to the Authentication and Authorization System for groups and users of the system.
- The second component refers to the specific functionalities of the Information System for the development of the Learning Assessment System by Rubrics.

The main functionalities shown in Figure 3 are:

- User and Group Authentication and Authorization System.
- Assignment: this functionality allows the user to associate a task with each class.
- Ed classes: this functionality that represents a single entity of a class.
- Enrollment: this functionality represents the enrollment of a specific student in a class and semester.
- Rubrics: this functionality allows the teacher to create a rubric according to their needs.
- Semester: this functionality represents a specific semester registration.
- Standards: a template that represents standards associated with the criteria and dimensions of the rubric. The user can choose more than one template or even no template.
- Students: this functionality represents an instance of a student.

TYPES OF RUBRICS THAT CAN BE BUILT WITH THE AID OF THE PROTOTYPE

The way we design and use rubrics can vary based on many factors, like how we use the assessment information in a given educational context. The rubrics may support student learning in different ways, such as facilitating the understanding of expectations and feedback, as well as through supporting students' self-regulated learning (Panadero, and Jonsson, 2020) and co-regulation learning (Fraile et. al. 2017).

The prototype has the interface shown in Figure 3 and functionalities described in Session 5.1. There are different types of rubrics used by researchers in the literature. The teachers must know these models so that they can choose with better precision the type of rubric that will serve as a template for their pedagogical activity. The main ones found in the literature are: scoring rubrics (Reddy and Andrade, 2010), adaptive rubrics (Carmosino and Minnes, 2020), formative rubrics (Pals et. al., 2023), multiple rubrics (Habib et. al., 2023), holistic rubrics (Wei et. al., 2021), methodological rubrics (Wu et al 2019), analytical rubrics (Boettger, 2010) and rubrics for task-specific or scoring rubrics (Arter and McTighe, 2001).

EXAMPLE OF RUBRICS THAT CAN BE BUILT WITH THE AID OF THE PROTOTYPE

In this section, we will exemplify a rubric whose pedagogical objective is to reflect on different computational solutions both individually and in groups.

The pedagogy objective is that programming students must understand that computational problems can be solved in multiple ways. The strategy used in this example is sharing and reflecting on different perspectives. A problem definition that to be formulated by the teacher according to the subject topic.

Contextualizing the rubric with the step-by-step task:

- (Individual) Each student individually writes the program code and tests the code to make sure it is correct (turn in the program code).
- (Collaborative) In a group, each student presents their code to the group and shows that the code passed the test cases provided by the teacher.

After the presentation, students reflect on the similarities and differences of each correct code and adapt the incorrect codes (Submit individually your interpretation of the discussion). Individually reflect based on the following questions:

- Did jointly evaluate different solutions help me understand that there can be more than one program to solve the same computational problem? (deliver).
- Did sharing different points of view help me learn to program? (deliver)
- Did I become more confident in the correctness of my solutions after the discussions? (deliver)
- Has sharing different points of view helped me improve the quality of my code? (deliver)
- Did sharing knowledge also allow me to share skills with my partners? (deliver)
- Did interactions in the group allow us to correct logic and syntax errors more quickly? (deliver)
- Did I feel more responsible for my participation in the work? (deliver).

The classification criteria by levels, in ascending order, of the holistic rubric can be seen in Table 2. The criterion used in the evaluation of the holistic rubric is the classification of what was done by the student in the teacher's evaluation in relation to the specific activity. In other words, the teacher's judgment classifies the answer into one of the five levels in ascending order of quality.

An important observation is that the grade of the rubric example (Table 2) can be applied individually or to evaluate the class. In the case of individual assessments, the grade will be the result of a specific student. In the case of class assessments, the grade will be replaced by a statistical analysis of the result, for example, the frequency of students classified as levels 1 to 5, respectively.

Table 2.: Contents of Levels of the holistic rubric exemplified

Level 1 (grade)	The student did not write the program code. He could not code anything. A summary of the discussions was not provided. Did not provide any response to the questions.
Level 2 (grade)	Coding an incomplete and untested program. Weak summary of discussions. Responded superficially to questions.
Level 3 (grade)	Coding an incomplete program, but tested the parts he did. Summary of regular discussions. Responded to questions in an average manner.
Level 4 (grade)	Coding a complete program and tested the parts he made. Good summary of discussions. Responded satisfactorily to questions.
Level 5 (grade)	Coding a complete program and tested the parts he made. Summarized the discussions excellently. Answered in depth to questions.

CONCLUSIONS

The rubrics, if they are well done and evaluated by standardized rubrics, provide teachers with an effective evaluation. Rubrics are cited extensively in Computer Science Education as excellent tools for measuring indicators for learning assessment.

They also allow for the elaboration of standard feedback on student performance, since they greatly facilitate an evaluation with well-defined criteria and dimensions and with standardized scales. The extended Pintrich's framework presented with the aid of rubrics here can have implications for practice, especially for facilitating students' social regulation. Thus, this study has the potential to provide valuable information for educators on the instructional design and selection of appropriate regulatory processes for shaping and evaluating learning activities to facilitate students' regulation during a learning assessment activity.

The proposed framework, exemplified by a real classroom example in this research, can offer teachers the opportunity to organize educational environments to facilitate and evaluate students' experiences and learn different types of regulatory learning skills.

It is important to mention the importance of recognizing the taxonomy of rubrics that can be used in different contexts in the classroom. References on the different types and purposes of rubrics are an important reference for researchers, as they present, in addition to a consistent theoretical framework, rich examples of their application.

The implementation of the prototype allowed us to observe practical aspects of the construction of rubrics. The description of the prototype's functionalities will help researchers who wish to build their own tool, according to the specificities of their research. The holistic rubric as a complete and contextualized example of didactic objectives applied to a classroom activity, in this case pedagogical objective is to reflect on different computational solutions both individually and in groups. This template was chosen in this example of rubric because it can be used individually as well as in a group evaluate a class as a whole using the most appropriate statistical tool for this purpose.

Learning assessment can be done with the help of the development of rubrics, and different types of assessments or tasks require different types of rubrics that can be reused in another educational context.

Constructing rubrics with appropriate criteria and dimensions is a labor-intensive process. The prototype developed is an important step for researchers to have access and ease in both creating and evaluating the rubrics, and making the prototype available can help other researchers in the area. At this time, due to the article submission rule, there should not be any type of identification of authors and institutions. Therefore, the link to the documentation and prototype source code cannot be presented at this initial stage of the submission process.

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