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Evaluation process in classical m: application of a progressive evaluation

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ABSTRACT

The teaching and learning processes aim to ensure the student encounters knowledge. The Theory of Objectification inserts the transformation of the being as an increase in teaching and learning. However, historically and traditionally, the basis on stimulus and response in expository classes suggests that teachers who possess knowledge, who "transmit" knowledge to students, are essential in the process and, in this case, the evaluation is mistakenly summarized as the application of tests such as knowledge tests. This work presents a progressive assessment method as a part of the teaching-learning process, an activity consisting of a challenge-exercise on the use of Lagrange formalism and Hamilton formalism to solve the movement of the double pendulum in a group, a proposal of joint work inspired by OT. Following resolution, interpretation of the statement was provided with critical reflection on the concepts, choice of procedures for resolution and reflective analysis of the results. It was observed that progressive assessment favored the transformation of students through their encounter with knowledge. Therefore, the application of OT in the evaluation process proved to be effective not only in attributing grades to students, following the standards, but also demonstrated effectiveness (or achievement) in the teaching-learning process.
KEYWORDS: Learning assessment; Physics teaching, Objectification Theory.

Processo avaliativo em mecânica clássica: aplicação de uma avaliação progressiva

RESUMO

Os processos de ensino e aprendizagem visam garantir o encontro do estudante com o saber. A Teoria da Objetivação (TO) insere a transformação do ser como incremento ao ensino e aprendizagem. Porém, histórica e tradicionalmente, a base no estímulo e resposta em aulas expositivas sugere que professores detentores do conhecimento, que "transmitem" o saber aos estudantes, são imprescindíveis no processo e, nesse caso, a avaliação é resumida, equivocadamente, à aplicação de provas como testes de conhecimento. Considerando-se esse contexto, apresenta-se, neste trabalho, um método de avaliação progressiva como um recorte do processo de ensino-aprendizagem, uma atividade constituída por um exercício-desafio sobre o uso do formalismo de Lagrange e do formalismo de Hamilton para a resolução do movimento do pêndulo duplo em grupo, uma proposta de labor conjunto inspirado na TO. Na sequência de resolução, promoveu-se a interpretação do enunciado com reflexão crítica sobre os conceitos, escolha dos procedimentos para resolução e análise reflexiva dos resultados. A atividade avaliativa foi fundamentada no labor conjunto com debate profundo sobre o enunciado e o procedimento de resolução, com os estudantes livres para manifestar suas culturas e suas perspectivas com base nos conceitos vivenciados ao longo do curso de graduação. Observou-se que a avaliação progressiva favoreceu a transformação dos estudantes pelo encontro com o saber. Portanto, a aplicação da TO no processo de avaliação se mostrou eficaz não somente em relação à atribuição de notas aos estudantes, seguindo as normas, mas, também, evidenciou a eficácia (ou conquista) no processo de ensino-aprendizagem. As posturas dos estudantes evidenciaram os processos de objetivação e de subjetivação durante as atividades em conjunto, com decisões baseadas na ética comunitária, em razão do respeito mútuo e da consideração recíproca entre os integrantes do grupo.
PALAVRAS-CHAVE: Avaliação da aprendizagem; Ensino de física; Teoria da Objetivação.

INTRODUCTION

Assessment practices in Higher Education traditionally take the form of in-person tests administered on predetermined dates by teachers or educational institutions, particularly in the physical and mathematical sciences. When used merely as assessment instruments, such assessments disregard teaching and learning as dynamic processes, in which students can learn from their own mistakes.

On the other hand, some researchers claim that assessment is the heart of the educational process, as in the assessment conducted within the educational system, as assessment of the educational system (Sant'anna, 2011), considering those involved in the process: teachers and students. For teachers, it serves as an instrument that informs and guides, through feedback, the quality of past and future pedagogical actions, and for students, it serves as a direct contribution to the way that they gain knowledge, through practical activities, as well as outside the classroom.

Traditional educational practices often reflect behaviorist assumptions, in which learning is associated with stimulus-response mechanisms and assessment is reduced to the assignment of grades.

Indeed, the assessment process is often completed by measuring — and issuing — a grade, even for bureaucratic and temporal reasons, without continuity, which would be the analysis and the reflection for decision-making regarding the next steps in relation to the knowledge developed in the classroom, being observed more frequently in Higher Education (Xavier et al., 2023).

Pezzi et al. (2025) conducted a systematic review of Higher Education assessment works and pointed out that there is a scarcity of research on this topic, suggesting that the discussion is even less extensive in Physics Teaching. The same researchers pointed that there is a resistance by teachers to abandon traditional methods (based on tests and summative assessments) and develop more innovative and formative assessment approaches (Pezzi et al., 2025).

This work will present a methodology inspired by the Theory of Objectification (TO) by Luis Radford (Radford, 2014; Radford, 2021; Vargas-Plaça; Radford, 2023b) as a way of considering a teaching and learning proposal in the assessment process, applying community ethics and dialectical materialism as a foundation for collaborative work in knowledge assessment (Teodosio; Scipião, 2022) in the Classical Mechanics course of a Physics teaching degree. The students' knowledge, culture, history, and political perspectives were considered throughout the collaborative work. Organized in groups, the students engaged in an interactive and dynamic process in which roles continuously shifted during the resolution of challenge-based tasks in Classical Mechanics. These tasks, carried out in multiple stages according to the nature of the problem, fostered both individual engagement and collective participation.

The encounter with knowledge related to Classical Mechanics, as well as the processes of historical and cultural conception, in teaching and learning, can promote the development of students as critical and reflective subjects, through paths distinct from those originating from processes centered on the learner which,

although they satisfy the dimension of KNOWLEDGE, are disconnected from BEING in its historical, cultural, political and social aspects (Radford, 2015; Radford, 2021).

The object of this research was the active observation (as part of the group) of a group of students in the assessment process practice and by the identification of the TO characteristics. Being a social process, TO guides observation not only by manifested language, but as whole, which includes written and body language, as well as interaction between the members of the group, favoring the reciprocal access to individual cultures, a potentially transformative process. As an active observer, the teacher gives up passive behavior evident in traditional tests, aiming to adopt an active and integrated stance with the students, thus becoming part of the group. In turn, as a member of the collaborative work in the assessment process, teacher moves away from the central role, as if he were a judge or an inspector of tests, and he assumes the guiding role by considering the students' expressions and, without giving them ready-made answers, encouraging them to jointly search for and acquire awareness of the presentations presented in the challenge-based tasks.

EDUCATIONAL ASSESSMENT

In the educational field, assessment is a complex and multidimensional social practice, permeated by ethical, political, and social values. It is not restricted to a purely technical dimension but reflects the conceptions of education and the formative objectives of a course or institution.

Assessment must be integrated into a political-pedagogical proposal of the course, reflecting its values, beliefs, and educational goals. This implies that assessment methods must be aligned with the proposed training concept, whether it is more traditional, student-centered, or focused on specific competencies (Oliveira et al., 2021). Furthermore, the assessment must be consistent with the integral education, considering not only the specific knowledge but also the socio-emotional aspects, collective work, and creativity.

Pezzi et al. (2025), in a review work, point out that the empirical-theoretical corpus shares common characteristics regarding assessment in Higher Education, namely:

(i) it is indissociable from the teacher's teaching practices, the students' learning methods, and the educational policies of the curriculum (…);

(ii) it is assumed as a collective produced social, cultural, and historical practice, intertwined with symbols and meanings (…);

(iii) it is procedural and permanent, being conducted throughout the period in which the course or curricular unit takes place, and not punctual and momentary (…);

(iv) it allows monitoring of the educational process and encourages the creation of conditions for improvements in learning (…);

(v) Its nature is certifying, controlling, judging, and issuing value judgments on the part of the teacher, based on their culture, feelings, ideology and personal preconceptions (…);

> (vi) it encourages autonomy, self-criticism, and reflective action on the part of student and the teacher by promoting self-assessment (...);
>
> (vii) it enhances feedback and dialogue among those involved as essential conditions for progress to be made in this domain (...).
>
> (Pezzi et al., 2025, pp. 07 and 08).

Although these are desired characteristics of assessment in Higher Education, actions must be always taken to ensure that these can be implemented, at any time and in any course.

Thus, it is crucial that assessment processes are carefully planned and implemented to effectively contribute to the students' learning process and to the achievement of the desired formative objectives. In this sense, Oliveira et al. (2021) reflect, based on the movement of reviewing conceptions about assessment, based on the studies of Biggs (1998), that Constructive Alignment would be understood as "a way of planning classes in which teaching and assessment actions are aligned so that there is an active involvement of the student, in order to achieve the intended objectives" (Oliveira et al., 2021). In other words, assessment would not be a moment that takes place at the end of a given period or content but rather is planned from the beginning of the course's design, considering the objectives of the knowledge to be developed in the classroom.

According to Bueno and Gonzalez (2019):

> (...) assessment is not only a component that occurs only at the end of the course to highlight results, but rather, from the teacher's planning, as it permeates the entire process, reshaping it whenever necessary, providing resources for the teacher, presenting various designs, because "it only makes sense to the extent that it serves to diagnose the execution and the results that are being sought and obtained. (Bueno & Gonzalez, 2019, p. 4)

This planning, with the prior inclusion of what should be developed, expected by the students, and evaluated, should occur in any educational context. In Higher Education, the syllabi do not specify how the practices should occur, but what should be developed.

Some works reflect on the role of assessment, from a perspective of looking at what has been happening in Higher Education. Barbosa et al. (2019) develop educational activities related to the knowledge of Physics to be developed in a teacher training course, linked to evaluative activities, and observe indications of the possibility of meaningful learning of Physics content, available for the teaching-learning process and basic assumptions that would be positions in relation to what is proposed.

Xavier et al. (2023) seek to identify the learning difficulties of students in a biological sciences course and find, through responses to analysis questionnaires, that the subjects of Physics and Calculus I were identified as the most difficult. The authors suggest the possibility of tutoring to reduce this gap.

It would therefore be necessary to pursue the challenge of making assessment a natural part of educational practice, perceiving it as an integral part of the teaching-learning processes, with diagnostic, summative, and formative functions.

Diagnostic assessment is configured as an instrument initially proposed in a course or presentation of added content in which it becomes necessary to diagnose what students already know. or have already experienced. This contributes to allowing teachers to reflect on their syllabus of content and pedagogical actions and even the way they conduct themselves, regarding the collective and individual needs of the students. Bueno and Gonzalez (2019) mention that:

> Diagnostic learning assessment, then, will be an instrument to guide new directions, stimulating reflection on actions carried out by teachers, which will entail the responsibility for them to rethink their practices, so that this will serve as an aid for the students' progress and not a burden for either. (Bueno & Gonzalez, 2019, p. 7)

It is observed that the authors reinforce the importance of assessment in the educational field, including in Higher Education, as a guiding instrument for practices, while at the same time proposing, to a certain extent, reflections by the student on the knowledge acquired so far.

The summative assessment, conducted at the end, aims to verify, from everything that has been worked on, whether in a field of knowledge or in each period, whether the students have achieved the expected success. This assessment function is more associated with the processes of passing/failing in subjects and with a more holistic view of all the pedagogical development conducted in the classroom.

Pezzi et al. (2025), supported by Garcia (2009) and Melo and Costa Neto (2020), mention that assessment practices in Higher Education are often limited to summative procedures, reflecting an entrenched view of a traditional assessment process and "lacking formative approaches that do not address contemporary educational challenges, nor reflect the desired quality criteria (...)" (Pezzi, et al., 2025, p. 13).

Formative assessment is that which should be conducted continuously, in the middle of the teaching-learning process, seeking to obtain continuous feedback, being recognized as an assessment for learning. This assessment function contributes effectively to teachers and students, given the proposal to be conducted continuously, fostering a certain dialogue around those involved in the process.

In this sense, Villas Boas (2017) mentions:

> formative assessment is the process by which all activities being developed and those completed by students are continuously analyzed, so that they and the teachers can identify what has already been learned and what remains to be learned, to provide the means for everyone to progress without interruptions and setbacks. (Villas Boas, 2017, p. 157).

This analysis enables the structuring or restructuring of pedagogical work with the aim of ensuring that students have opportunities and incentives to discover knowledge and, consequently, to promote individual transformation. Through this evaluative function, no aspect is neglected, and each student's needs are addressed in an individualized manner. In addition, it is noted that, due to the characteristics mentioned, and what is widely discussed in the field of educational assessment, there are different arguments in defense of this function of assessment, both in the academic sphere and in various guiding documents for schools, in Brazil and around the world.

It is perceived that this is the understanding associated with objective and subjective conditions, which can lead to the use of this evaluative function only as a classification tool, thus using this tool incorrectly.

Furthermore, formative assessment aims to serve learning and, at the same time, support the student in their curricular formative trajectory. Additionally, Hadji (2001) mentions that formative assessment should favor the regulation of learning, guiding students in their difficulties, enabling them to take actions that contribute to their progress, and continues:

> from this perspective, error would not be a fault to be repressed, but a source of information, both for the teacher — whose duty is to analyze the student's work and, through it, their situation — and for the student, who needs to understand their error in order to avoid repeating it and progress. (Hadji, 2001, p.10 – emphasis added).

Thus, error naturally arises as a fundamental element of the teaching-learning process, whose objective is to contribute to the teacher's work, so that students succeed and not just serve for recrimination. It is essential that evaluative activities, including formative ones, do not end in measuring, but advance to evaluating, from a perspective of inclusion, welcoming and helping the student (Oliveira, et al., 2021).

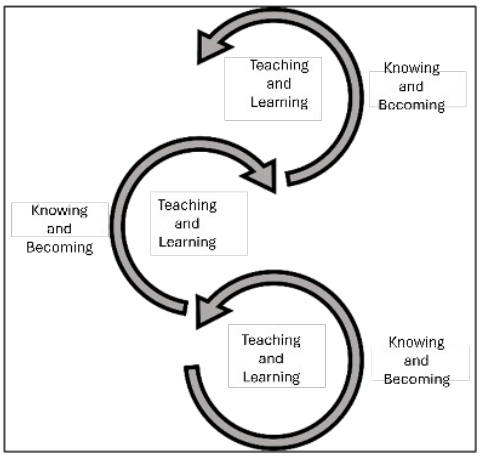
In addition to the complex challenges of educational assessment, particularly formative assessment, the challenge in this context is to make assessment actions one of the aspects that contribute directly and effectively to the application of TO, that is, that assessment processes are not detached from theory, located only at the end of the whole process, but rather, are concatenated and intrinsic to theory and, consequently, to teaching and learning.

THEORY OF OBJECTIFICATION

Considering TO as the foundation for the assessment process, the proposal is to address the dimensions of BEING (subjectivation) and KNOWING (objectivation), becoming more comprehensive than the traditional method of administering a test, which is known to be alienating because it does not establish continuity. The application of TO establishes continuous assessment processes, which may be termed "progressive assessment." Because it is dynamic, the assessment process therefore favors the permanent transformation of BEING through KNOWING, as schematically presented in figure 1. Ethical and reflective subjects emerge because of considering knowing and being inseparable in their political, social, historical, and cultural attributions (Radford, 2014; Radford, 2021).

Figure 1

Representation of the teaching-learning process in TO, explicitly showing the constant evolution of Being through Knowledge



Source: author's own work, based on Radford (2014).

At first glance, it can be argued that applying a teaching-learning process that considers both knowing and being satisfies community ethics and collaborative work, given that participants can be together in the activity, effectively supporting each other, in sync and in harmony, both in terms of the responsibilities assumed and in the individual and collective efforts to overcome challenges.

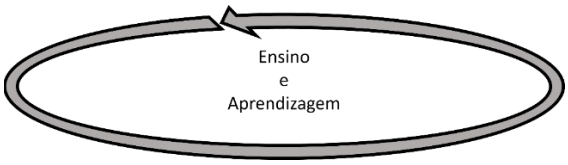
According to OT, activities are not simply doing something but are fundamental means for the action and interaction of subjects. In this sense, during the activities, each participant should be considered in their entirety, with their identity established in their cultural, social, historical, and political development (Radford, 2015; Moretti, Panossian, Radford, 2018).

Also, in figure 1, each teaching and learning cycle represents a process that involves the group participants in collaborative work. Therefore, the evolution of teaching and learning cycles resulting from collaborative work does not represent individual progress, but collective progress with the participation of all, promoting the encounter with knowledge and the transformation of being.

Traditional teaching methods are focused solely on specific knowledge of the curricular content, disregarding the identities of the students. This practice produces a distortion in teaching and learning (figure 2) because it aims at the development of knowledge without considering the transformations of being. These are technical methods that lead to mechanical procedures, making it impossible for the student to encounter their own culture, disregarding creativity, that is, disregarding reflection and criticality. In this case, the tendency is superficial satisfaction, although there may be cognitive conflicts in the face of the false consonances that arise from the illusion of knowledge. This illusion originates when the student shows mastery of the technique, presenting the expected results in the exercises, without the transformation occurring. Unlike figure 1, figure 2 presents a permanent cycle, a distorted conception of the teaching and learning process.

Figure 2

Distortion in the teaching and learning methods undervalue the individual



Source: author's own work (2025).

Teaching and learning can even consider the socialization of activities carried out individually. In this sense, it is an in-individual activity performed by participants close to each other. However, for effective emancipation through transformation of being, it is not enough for participants to be close to each other; it is essential that they interact, sharing their knowledge and being willing to undergo the transformations to which they are subject.

Therefore, the effective adoption of community ethics involves complicity and harmony among the protagonists of a given activity, a common goal achieved by all, in which each participant (teachers and students) collaborates in a joint effort (Radford, 2023a; Radford, 2023b). Tasks are applied dynamically, respecting the organization agreed upon.

According to Radford (2023a), community ethics is organized around three axes: commitment, care for others, and responsibility. Committing to joint work means dedicating oneself to actions with the group in a profound way. Caring for others means having an active attitude not only in one's own functions but also paying attention to others in their tasks. Responsibility is the recognition of belonging to the group and that one depends on the other to achieve the objective. Collective learning implies considering the three axes mentioned in balance, aiming to overcome challenges as a group. Therefore, there are no activities for the teacher and activities for the students; teachers and students conduct the activity together, each with their own function (Vargas-Plaça; Radford, 2023a), respecting each other and leading towards the evolution of knowledge through the teaching-learning process.

Based on Paulo Freire's perspective, the application of TO aims at the transformation of the subject through reflective and ethical procedures, providing the improvement or creation of innovative ideas and thoughts (Radford, 2023a; Vargas-Plaça; Radford, 2023b). However, unlike theories built with a focus on the learner, culminating in individualistic learning, TO addresses the themes considering the history and culture of the members of the didactic sequence, with each participant performing their function, but the group achieving knowledge collectively, with unrestricted access to their respective cultures, respecting community ethics.

Group work, in fact, by involving efforts for cooperation and collaboration, allows for social, historical, and cultural interaction, favoring the exchange of personal information and the identification of the knowledge of other participants, promoting transformations of being. These are processes in which oral language is only one of the many forms, as body language can be an important source of information in teaching and learning, in addition to communication through

images, engravings, drawings, perceptions, which are the semiotic means of interaction (Silva, Almeida, 2021).

Since the transformation of being and the acquisition of knowledge are inseparable processes, in TO they occur through efforts in actions during activities, that is, through joint work. Joint work in TO must be designed in such a way that those belonging to the group interact considering their identities, namely: culture, society, history, and politics (Ayres et al., 2022). Thus, it will be possible to satisfy the process of transformation of being in harmony with knowledge, ensuring solidarity in overcoming the challenging exercises. Activities in joint work include teachers and students, each with their own function. Because it is a dynamic process, individual functions can be alternated among participants, who assume responsibilities according to their previous transformations, aiming at those they aspire to achieve.

The functions assumed are based on a horizontal hierarchy, in which all participants organize themselves by consensus and identify their roles during the activity. For example, the teacher does not assume the role of absolute knower of the content and the one responsible for "transmitting" it to the students. On the contrary, it will be the teacher's responsibility to provide activities that guide the encounter of knowledge, with interaction ensuring consideration of the individual in their cultural, historical, social, and political aspects, not as a mediator, but in the position of belonging to the whole, interacting with the students and with the objects (Batista, Oliveira, Pereira, 2021).

METHODOLOGY

Considering the environment that characterizes the stage for teaching and learning from the perspective of OT, as well as the guidelines related to the participants, this work reports an experience of applying an assessment process in the Classical Mechanics course for a Bachelor's degree course in Physics, in the 2023/1 semester, at a Federal University, with the constant presence of 8 students.

This study adopted a qualitative research approach aimed at identifying processes of objectification (knowing) and subjectification (becoming).

In this sense, according to Freitas (2002):

> qualitative studies from a socio-historical perspective, by valuing descriptive aspects and personal perceptions, should focus on the particular as an instance of the social totality, seeking to understand the subjects involved and, through them, also understand the context. (Freitas, 2002, p. 26).

In other words, the analysis takes place through various aspects of dialectical interaction that permeate the reality of pedagogical practices developed in the classroom and, in this case, of assessment practices, considering the social being and the cultural being.

Complementally, regarding observation, a methodological process that will be carried out in this work, Freitas (2002) comments:

> thus, observation should not be limited to the mere description of singular facts; its true objective is to understand how one thing or event relates to other things and events. It is,

> therefore, a matter of focusing on an event in its most essential and probable relationships. The more relevant the relationship that can be gleaned in a description, the more possible it becomes to approach the essence of the object, through an understanding of its qualities and the rules that govern its laws. The more the richness of its qualities is preserved in an analysis, the more possible it is to approach the internal laws that determine its existence. In fact, only by gathering the most important traits and then the more secondary ones, identifying their consequences, do the relationships that link them to each other begin to emerge clearly. The objective of observation is thus enriched by a network of relevant relationships. (Freitas, 2002, p. 28).

This reinforces the complex aspects involved in observation, starting with more pragmatic and specific analyses, going through aspects that may arise from the quality of the observation and what can be highlighted, seeking congruences and incongruences.

Particularly about TO, there are guidelines on how to conduct the analysis of interactions in teaching and learning contexts, that is, the semiotic modes to be observed during the interaction between subjects.

Camilotti, Vargas-Plaça and Gobara (2019), supported by Piccinini and Martins (2004), comment that the semiotic modes to be analyzed are verbal, gestural, and visual. The authors, based on Veneu (2012), also point out that the analysis should be carried out using an adapted device, starting with the identification and selection of statements (which are the moments of the relevant episodes), moving on to the preliminary analysis of the statement, followed by the description of the extra-verbal context and ending with the analysis of the statement (Camilotti; Vargas-Plaça; Gobara, 2019).

Regarding this work, related to assessment practice, the focus was on verbal aspects (speech and writing), mainly described during the resolution of the challenge-based task and, after the return, collective reflections (teacher and students) on the errors made. The device analyzed was the statement of the challenge-based task together with the resolution presented in written form. The proposal was a debate about the statement by the group of students, focusing on the didactic resource to support the concepts necessary for the resolution procedure. The concepts covered are the result of knowledge acquired during the undergraduate course, characterized as cultural elements that support the debate on the proposed challenge-based task. After solving the problem together, each student must present their description of the solution, which becomes a new element of debate, regardless of whether it contains errors in resolution or interpretation, for which assessment grades are assigned. If errors occur, they are used to highlight students' developmental processes, as they are supported in the next stage. With the understanding of the errors, the group of students makes the decision, individually or collectively, to continue or not with the resolution. If the decision is to interrupt the resolution, the assessment grade has already been assigned. If they decide to continue, the grade may (and certainly will) be modified, considering the debate on the errors in the resolution. This procedure allows the assessment process to be integrated with the other teaching-learning activities.

The topics covered from an OT perspective, in person, were the following:

- 2D motion;
- Lagrange and Hamilton formalism; and

• orbits under central forces.

The in-person classes were organized as follows:

• **concept classes:** presentation of the main physical concepts in Classical Mechanics, conducted with encouragement for dialogue and the expression of ideas;

• **challenge classes:** presentation of challenging exercises with the aim of joint resolution through the application of concepts.

The concepts required advanced mathematical treatment. However, there was encouragement for student participation and the expression of their ideas before, during, and after dialogue on the topic in question. In classes on physical concepts, the historical and social context associated with the protagonists of the development of ideas and procedures was also considered. In this sense, it can be stated that there was no expository class, since the historical and social contextualization favored student participation because they tended to relate it to their own routines.

For each of the Classical Mechanics topics indicated above, students were asked to solve a challenging exercise, the same challenge for everyone. These exercises were considered assessment activities, and the procedure followed these steps:

1. General guidance on the activity;

2. joint reading and interpretation of the presented problem;

3. dialogue about the described physical phenomenon;

4. adjustments to the interpretation of the text;

5. schematic representation of the phenomenon and indication of the forces applied to the objects considered;

6. consideration of the sequence of movements, when applicable;

7. global interpretation of the described phenomenon, considering the applied forces and their consequences;

8. structuring and organization of calculations;

9. application and analysis of the mathematical equations that represent the movement in each of the sequences of the phenomenon;

10. comparison of the equations with other known equations;

11. determination of the values and verification of their consistency in relation to the phenomenon described;

12. general considerations and interpretation of the movement of the objects throughout the entire extent requested by the problem statement.

This procedure constituted knowledge assessment. Students were free to discuss the challenge in class, always with the teacher's participation. Furthermore, no deadline was set for the solution, considering that each student has their own learning pace, which was respected, and it was considered a progressive assessment.

Traditional examinations were therefore not administered. Instead, students were encouraged to engage in open discussion and collective reflection, shifting the focus from grades to learning and conceptual understanding. As part of the course planning, all students were guaranteed a maximum grade for participating in the progressive assessment. The following grading procedure was adopted:

1. after each resolution sequence, students shared their results, obtained jointly, with the teacher;

2. the mathematical treatment could also be done jointly; however, each student preferred to do it individually to legitimize the dialogues for interpreting the results;

3. if conceptual or calculation errors were identified, each student's result was returned to them with guidance on correction procedures;

4. students could then decide whether to continue working on the problem, correcting their mistakes and proceeding with the challenge-based task. If the student decided to stop, the grade was assigned, but they could return to the solution later;

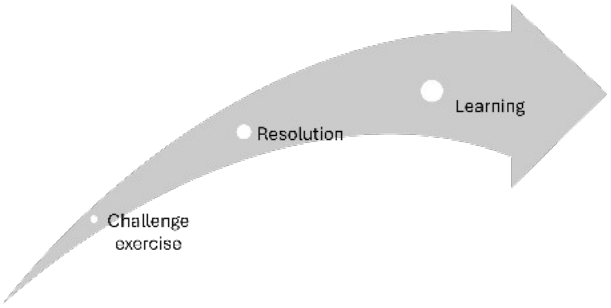
5. this procedure would continue, if the student wished, until the complete solution. The grade assigned would therefore be 10 (on a scale of 0 to 10).

It should be noted that there is no linearity in the assignment of the grade if the activity is completed, that is, being a progressive assessment, the trajectory follows the necessary and appropriate pace according to the participants' manifestations.

Figure 3 represents the expected sequence for the teaching-learning process and figure 4, the flow that governs the assessment process.

Figure 3

Sequence applied to the assessment process



Source: Author's own work (2025).

Figure 3 represents the encounter between being and knowing in the teaching and learning process. In the case of the assessment process, in summary, when presented with a challenging exercise, students commonly tend to begin solving it. However, prior guidance on the activity and interpretation of the challenging exercise is necessary, and at this stage, the teacher can initiate collaborative work, encouraging students to reflect on the question's wording, identifying the main concepts, and deciding on the initial approach. It is observed that the main concepts are not those indicated by the teacher, but those that the students

themselves identify through dialogue and research, as well as those they recognize based on their cultures, histories, and human interaction. Therefore, it is not a matter of delivering a challenging exercise for the student to obtain a correct result, but a statement that allows each group of students to engage in effective debate, with the teacher's participation. The question reveals a cultural artifact conducive to promoting the encounter between being and knowledge and, consequently, the transformation of everyone.

In a natural and imperceptible way, due to the inseparable relationship between the stages, the resolution begins with the understanding of the challenge-based task statement and the established theoretical foundations and concepts associated with the proposal. This occurs naturally in the case of dialogue, as there is a prior understanding of the problem situation. In the resolution process, there are the conceptual obstacles characteristic of a challenge, which require interaction between the group participants in the search for appropriate directions that lead to overcoming them. The teacher collaborates, in these cases, with stimuli and, if the group is following an inadequate or mistaken direction, intervenes by guiding the students. However, the teacher should never provide the answer or the path to be followed by the group, as this influence interrupts the cognitive process, preventing students from seeking their transformations through knowledge.

Finally, the encounter with knowledge occurs through overcoming challenges and solving exercises. The transformation that takes place is due to the entire process, from the guidance and interpretation of the statement, through the joint work in which all members of the group carry out their activities in reciprocal harmony, with complicity towards the common goal, taking care of each other in the sense of joint learning.

Figure 4 represents the flow of the assessment process, a suggestion for applying TO with the objective of providing activities that promote the encounter with knowledge and the transformation of being with the assignment of a grade, respecting academic rites. The focus should not be only on the result, as this would be contradictory to the precepts of TO. It is necessary to consider the assessment process, with the aim of the transformation of being, which promotes its critical-reflective perception on the subject addressed. With this, it will not remain at the stage of repeating concepts, applying the subject matter in a technical way, as in a mechanical process, but will be able to reach more advanced levels of creativity, being able to develop situations that were previously unthinkable and solve challenges that had never been observed before.

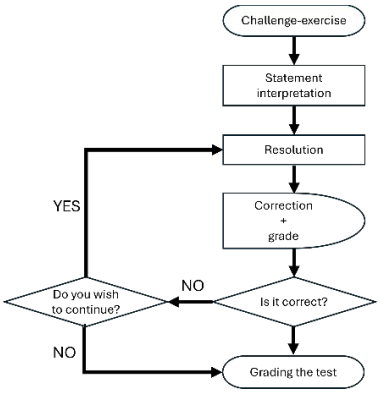
In this way, there was no test, but an assessment process whose objective was not a test of knowledge, but to promote learning. The freedom to execute the challenge was a decisive factor in breaking the paradigm in relation to the tests traditionally applied.

As shown in figure 4, the assessment process may include a stage of teacher participation in reading the solution prepared by the group. If there are mistakes, the teacher identifies them, without presenting the answers, and returns them to the group so that they can proceed with the correction and redirection of the solution. In this case, the teacher may also give a grade to the group, which, in turn, has the option of interrupting the assessment process if it is satisfied with the

grade assigned, a measure adopted in the extreme case of interrupting the progressive assessment. On the other hand, if the group decides to continue, it may achieve the highest grade. In all cases, the goal is to ensure the transformation of each participant in the group through the encounter with knowledge.

Figure 4

Flowchart for organizing the assessment process



Source: Author's own work (2025).

ANALYSIS AND RESULTS

The Classical Mechanics course in a higher education course in Physics, taught after the basic cycle (basic physics, calculus, linear algebra, among others), uses mathematical resources such as differential equations, convergence and expansion of functions, non-linear equations, in addition to more refined conceptions of natural phenomena (for example: coupled oscillators, movements under air resistance, systems from the perspective of Lagrange and Hamilton formalisms, etc.).

Traditionally, it is a course with high demands on students. However, there is a misconception between being demanding and administering in-person exams for a predetermined period (usually two hours), with pre-scheduled dates and complex in the form of a test. However, the demand is not related to the complexity of the exams, but to the teaching-learning process throughout the course. In this sense, it can be said that there was a change in thinking by proposing a break with traditional assessment methods.

Among the disagreeing aspects, the traditional test, applied on a specific day, prevents the student from critically reflecting on the statements, distances itself from dialogue as a teaching and learning resource, makes learning from mistakes impossible, stifles the creative process due to the restricted time for resolution, and is therefore an alienating resource. There is also the understanding that students should be subjected to complex tests to learn the concepts, a proposal based on behaviorism and whose learning process occurs through repetition and stimulus-response.

In contrast, the adoption of a progressive assessment method inspired by TO favors critical reflection, reflective dialogue, and creativity, becoming a resource of the teaching-learning method, of which the test can be one of the elements, but not the only one. In addition to being progressive, the process is interactive,

fostering collaborative work and, consequently, the transformation of being through knowledge by accessing the cultural elements expressed in human relations, characterized by the processes of objectification and subjectification.

When considering the application of TO in the assessment process, the dialogical aspects, semiotics during classroom activities, and community ethics were considered, with collaborative work being a constant premise encouraged by the teacher, who also belonged to the group. The group was therefore composed of teachers and students, with distinct roles, but with the same objects and objectives: encounter with knowledge and transformation of being. Applied in accordance with the precepts of TO, the teacher is removed from the position of sole holder of knowledge, that is, the teacher becomes an integral part of the group, belonging to the didactic-pedagogical environment. In this same sense, the student also does not become the center and, naturally and progressively, adopts an ethical stance as part of a group, in which everyone has functions determined according to their understandings by their own cultural reservoir.

With the application of TO in progressive assessment, authenticity and legitimacy are guaranteed in the process of encountering knowledge through the dialogical treatment of the interpretation of the physical phenomenon addressed and through the use of mathematical resources, promoting its transformation, since no deadline was set for the activity and learning through mistakes was provided, allowing each one to achieve the maximum grade. Each participant develops their own solution, in their own way, although supported by joint work, given that the process is sustained by interaction. In this sense, the interactions highlight cultural aspects hidden in individual tests, satisfying dialectical materialism as a basis for solving challenges.

The purpose of the challenge-based task is not to embarrass students or trivialize the subject matter, but rather to provide a progression of challenges that can be gradually overcome. For this work, a case study of the application of a challenge-based task was used as an example, considering the students as beginners in the Lagrange and Hamilton methods in Classical Mechanics. After this application, once the students have overcome this challenge, another more challenging exercise is presented; however, because it is a gradual process, the students do not feel pressured and can solve the problem by covering the concepts in a step-by-step manner, without content jumps.

Figure 5 represents the challenge-based task applied to students enrolled in the Classical Mechanics course in the Physics Degree program. For its elaboration, it was considered that the students master the necessary physics and calculus concepts, identified through previously applied activities, involving critical-reflective dialogue. The identification of culture conducted collectively favors the process of objectification and subjectification, as it enables participants to engage with culture collectively.

Knowledge is acquired through interaction, with each subject highlighting certain historical and cultural elements.

In the process of solving this exercise (figure 5), considered as a teaching and learning activity and not a test, the students began by discussing the statement, applying community ethics, observing the details of the system (double pendulum), and considering the possible movements of the bodies.

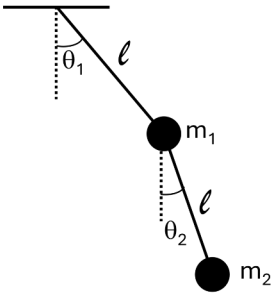
The resolution stage (figure 3) should not begin immediately after reading the statement, but simultaneously with the initial understanding of the concepts. In this stage, students are encouraged to interpret the phenomenon presented and to verify the numerous possibilities for beginning the resolution, thus being characterized as a planning stage. With this, students produce means of investigating the phenomenon presented, considering the concepts addressed.

Far from being a mechanical and static process, the problem-solving method inspired by OT is dynamic, a practice of collaborative work with community ethics, which favors the use of artifacts, resources, and concepts as the problem-solving process unfolds.

Figure 5

A challenging exercise applied to students of the Classical Mechanics course

A double pendulum is characterized by containing two cords of equal length (ℓ) and two equal masses (m), as shown in the following figure. For this system, determine what is requested.



a) Write the Lagrangian of the system and the Lagrange equations of motion.
b) Write the Hamiltonian of the system and the Hamilton equations of motion.

Source: own work (2025).

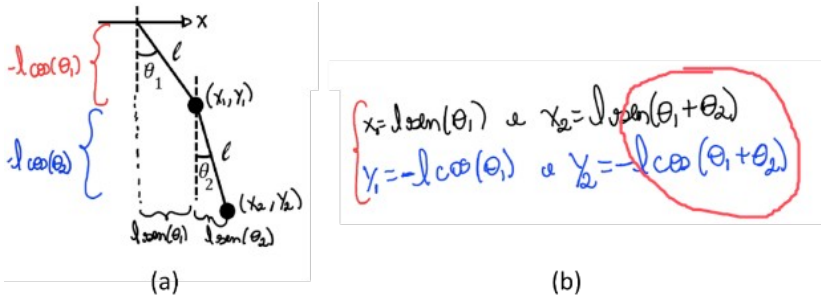
Once the problem-solving process begins, the teacher actively participates in the discussions, without directly interfering in the students' decisions. The procedure of reading the solutions shared by the students involves analysis by the teacher and is presented as a means of communication, part of the joint work. Figure 6 represents a part of the solution to the challenge-based task based on the double pendulum (figure 5). In their first interpretation, the students included the projections of the string length in relation to the angle of inclination of each pendulum.

Figure 6a represents one aspect of the interpretation of the statement and the consideration of the projections of the length of the pendulum strings, correctly presented by the students. Diagram (a) was presented by a student and represents a result developed by the group. In part (b), when representing the projections of the length on the x and y axes, there was an error, since the length of one of the wires was considered for the position of the lower pendulum (2), but, erroneously, the sum of the angles θ_1 and θ_2. The procedure should consider the sum of the projections of the lengths of the wires in the expression for the position of pendulum 2, that is:

$$\begin{cases} x_2 = & l\,sen(\theta_1) + l\,sen(\theta_2) \\ y_2 = & -[l\cos(\theta_1) + l\cos(\theta_2)] \end{cases} \quad (1)$$

Figure 6

Representation of the double pendulum diagram (a) containing the projections of the wire lengths and determination of the projections (b) related to the wire length and angles of inclination

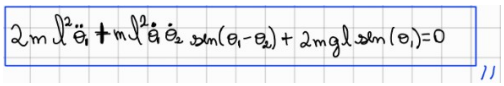


Source: student's solution

Although the student performed the calculation correctly, the misinterpretation and misexpression of the position of pendulum 2 (x_2 and y_2) generated an incorrect Lagrangian (figure 7).

Figure 7

Representation of the Lagrangian of the system (double pendulum) with a misinterpretation at the origin

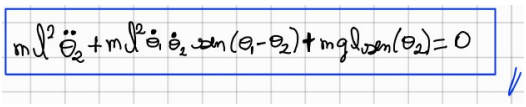


Source: student's solution (2025).

Consequently, the equation of motion generated from the Lagrangian is also incorrect, as shown in figure 8.

Figure 8

Representation of the equation of motion of the system (double pendulum) from the Lagrangian of the system, with a misinterpretation at the origin



Source: student's solution.

In the case of the double pendulum motion challenge problem, the correct expressions for the Lagrangian and the equation of motion are, respectively:

$$2ml^2\ddot{\theta}_1 + ml^2\ddot{\theta}_2\cos(\theta_1-\theta_2) + ml^2\dot{\theta}_2^2\,sen(\theta_1-\theta_2) + 2mgl\,sen\theta_1 = 0 \quad (2)$$

$$ml^2\ddot{\theta}_2 + ml^2\ddot{\theta}_1\cos(\theta_1-\theta_2) - ml^2\dot{\theta}_1 sen(\theta_1-\theta_2) + mgl\,sen\theta_2 = 0 \quad (3)$$

Source: student's solution (2025).

This result was not shown to the students, as confidence should be placed on the procedure, not just on the answers, which must be earned by the students.

The solution containing comments and an indication of the mistake (as well as verbal guidance to the group, a practice of collaborative work) was returned to the student, who shared it with the group. Therefore, they had the opportunity to gain experience from the error, correcting their calculations and then continuing with the exercise. In this way, there is no permanent error in an assessment, as students can correct their mistakes if they wish, which will contribute to raising the final grade and, more importantly, to developing confidence in interpreting problems, a consequence of the transformation of being through knowledge, since correction is also carried out through the application of collaborative work.

The grade assigned to the resolution of a challenge-based task, therefore, is dynamic, in the sense that it undergoes changes intrinsic to the assessment process, effectively representative of the encounter with knowledge. One of the students in the group who partially solved the double pendulum challenge problem, whose equations are presented in figures 6, 7, and 8, decided not to proceed with the correction, claiming that there were other subjects with tests and assignments. Her decision was respected, and the grade assigned was 8.00 (on a scale of 0 to 10.0). For the assignment of the grade, it was considered that the student made a mistake in the interpretation, but the other mathematical and physical concepts used were correct.

The resolution and solutions were debated among the students, with the participation of the teacher, in a joint effort, considering dialectical materialism. The errors made were corrected during the debates, without the teacher providing answers, with the teacher's role being to encourage the search for ways to obtain the answers, always based on the students' comments. In other words, the answers to the exercises were not the focus, but the consequence of the dialogues. The students overcame the (traditional) tendency to access the answer to the exercise and then proceed with (pseudo)confidence, recognizing that teaching and learning occur throughout the entire problem-solving process. In fact, the participants observed that learning occurred through their mistakes. There was appreciation for their achievements and for overcoming mistakes. In fact, the student who interrupted her participation expressed her wish to the group before deciding, demonstrating respect and consideration for her classmates.

With everyone participating in collaborative work, cultural, historical, political, and social aspects were observed, as established by TO, through the sharing of information and through written and body language, in addition to verbal language.

FINAL REFLECTIONS

In teaching and learning processes, all resources must be inseparable, although their characteristics are distinct. Among these, the assessment process assumes a prominent position, considering that, upon reaching this stage, students have already gone through other activities. Therefore, lesson planning must include the assessment process in its organization, precisely because it is one of the stages that guarantees students the opportunity to actively participate in actions that promote their own transformation.

The Theory of Objectification, in turn, presents elements that favor the transformation of the individual through their encounter with knowledge, valuing them in their daily lives and in their history and culture. The application of community ethics in collaborative work favors the appreciation of the individual by adopting care for others, harmony among group participants, and authentic dialogue that establishes harmony through mutual respect worked on by the group. This is an ideal that, if it cannot be achieved, remains a reference for the transformation of subjects. The student's decision to leave the group due to commitments in other courses is a demonstration of community ethics, as the student discussed it with the group before deciding.

Applied to assessment (which is different from a test), TO complements the teaching-learning process with an activity integrated with the others, highlighting progressive assessment in which groups are subjected to challenging exercises, whose resolution occurs gradually until the answer, in the following sequence: interpretation of the statement, application of resolution methods, and analysis of the result. The interpretation of the statement occurs through critical-reflective dialogues among the group members, identifying the concepts and planning the resolution; in this phase of progressive assessment, one of the main characteristics is the application of community ethics in joint work so that the students' participation favors the encounter with knowledge. The application of problem-solving methods requires students to seek paths according to their individual knowledge, present in cultural elements, without being forced to use imposed methods, but the most appropriate according to their own interpretations. Obtaining the answer, in turn, is a consequence of the procedure adopted, and its analysis is fundamental to identifying whether there is coherence. Figure 4 presents a suggested flow for solving a challenge-based task within community ethics.

From the student's perspective, there is a path between knowledge of concepts and knowing, in which knowledge is one of the elements, in addition to acquired creativity, critical reflection, and the power of synthesis and analysis, an encounter with knowing. This path favors the transformation of being through the processes of objectification and subjectification according to TO.

From the teacher's point of view, by accompanying the groups, they observe the manifestations through written and verbal language, as well as through bodily expressions, allowing for adaptation of the initial planning and additions to the dialogues between the students.

This study highlighted the challenges involved in implementing the TO in Higher Education, particularly due to resistance associated with traditional teaching practices that provide limited opportunities for reflection, dialogue, and collaborative interaction. On the other hand, it presented the progressive assessment method, which favors the encounter with knowledge and the transformation of the individual in accordance with TO.

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