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To learn while teaching and the potential to activate monitoring and control mechanisms of understanding: study involving teachers in pre-service[1]

Cleci Teresinha Werner da Rosa [2]

Luiz Marcelo Darroz [3]

Jean Carlos Nicolodi [4]

ABSTRACT

This study focuses on analyzing the activity of learning while teaching, particularly relating its potential for identifying knowledge misunderstandings and uncertainties. From a study involving the participants of a project of monitoring classes in a Brazilian university, the investigation analyzed the awareness of such students in terms of favoring a class structure directed to identify learning gaps. The investigation used interviews to answer the following main question: Does the act of teaching in the form of monitoring allow its executor a metacognitive reflection? Metacognition was understood as the ability of subjects to monitor and control their understandings, which may be associated with the identification of knowledge misunderstandings and uncertainties. The results indicate that supporting students consider the activity a learning opportunity, especially when they are explaining the content. Moreover, the study indicates the importance of identifying understanding gaps as a way to qualify learning.

KEYWORDS: Knowledge misunderstandings and uncertainties. Metacognition. Physics learning.

[1] English version by Álvaro Becker da Rosa. *Email:* alvaro@upf.br.

[2] Doutora em Educação Científica e Tecnológica. Universidade de Passo Fundo, Passo Fundo, Rio Grande do Sul, Brasil. Orcid: http://orcid.org/0000-0001-9933-8834. *E-mail*: cwerner@upf.br.

[3] Doutor em Educação em Ciências. Universidade de Passo Fundo, Passo Fundo, Rio Grande do Sul, Brasil. Orcid: http://orcid.org/0000-0003-0884-9554. *E-mail*: ldarroz@upf.br.

[4] Mestre em Ensino de Ciências e Matemática. Universidade de Passo Fundo, Passo Fundo, Rio Grande do Sul, Brasil. Orcid: http://orcid.org/0000-0002-4999-104X. *E-mail*: 153754@upf.br.

Aprender ensinando e a possibilidade de ativar os mecanismos de monitoramento e controle da própria compreensão: estudo envolvendo futuros professores

RESUMO

Este trabalho se ocupa de analisar a atividade de aprender ensinando, particularmente relacionado à sua potencialidade para identificar incompreensões e incertezas do conhecimento. A partir de um estudo envolvendo participantes de um projeto de aulas de monitoria em uma universidade brasileira, a investigação analisou a tomada de consciência destes alunos em termos do favorecimento da estruturação das aulas para identificar lacunas de aprendizagem. A investigação recorreu a entrevistas para responder ao questionamento central: o ato de ensinar na forma de monitoria oportuniza ao seu executor uma reflexão metacognitiva? A metacognição foi entendida como a capacidade dos sujeitos de monitorar e controlar suas compreensões, o que pode ser associado à identificação de incompreensões e incertezas do conhecimento. Os resultados apontaram que os estudantes apoiadores veem na atividade a oportunidade de aprender, sobretudo, no momento em que estão explicando o conteúdo. Além disso, o estudo explicita a importância de identificar lacunas de compreensão como forma de qualificar a aprendizagem.

PALAVRAS-CHAVE: Incompreensões e incertezas do conhecimento. Metacognição. Aprendizagem em Física.

Aprendizaje mediante la enseñanza y la posibilidad de activar los mecanismos de seguimiento y control de la propia comprensión: un estudio con futuros docentes.

RESUMEN

Este artículo analiza la actividad de aprendizaje mediante la enseñanza, particularmente en relación con su potencial para identificar el desconocimiento y la incomprensión. A partir de un estudio que involucró a participantes de un proyecto de clase de monitoreo en una universidad brasileña, la investigación analizó la conciencia de los estudiantes en

términos de favorecer la estructuración de las clases para identificar brechas de aprendizaje. La investigación recurrió a entrevistas para responder a la pregunta central: ¿el acto de enseñar en forma de monitoreo proporciona a su intérprete una reflexión metacognitiva? La metacognición se entendía como la capacidad de los sujetos para monitorear y controlar sua comprensión del conhecimento, lo que puede asociarse con la identificación de desconocimiento y la incomprensión del conocimiento. Los resultados mostraron que los estudiantes de apoyo ven en la actividad la oportunidad de aprender, especialmente cuando explican el contenido. Además, el estudio hace explícita la importancia de identificar las brechas de comprensión como una forma de calificar el aprendizaje.

PALABRAS CLAVE: Desconocimiento y incomprensión del conocimiento. Metacognición Aprendizaje de física.

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Introduction

The search for methodologies that evidence the active role of the student in the learning process, promoting the construction of knowledge, is a recurring subject in research in the educational area (BERBEL, 2011). Among these methodologies are Tailored Teaching, Peer Instruction, Team-Based Learning, Project-Based Learning and others, as evidenced by Mota & Rosa (2018). Added to these, there are methodologies focused on explaining to peers or colleagues, of which "Learning by Teaching" stands out. In this methodology, the emphasis is on providing opportunities for students to explain content to colleagues and build learning through teaching, restructuring their understanding, even being able to remedy possible mistakes or gaps in their own learning.

Learning by teaching is not new, since it is common knowledge that when teaching something, one is learning. Or, as Seneca, one of the most important philosophers and writers of the Roman Empire, mentioned: "To teach is to learn" (DURAN, 2016). However, its use as a

teaching strategy has gained strength from active methodologies, in which the student becomes a protagonist in the knowledge construction process and must assume the condition of active producer and evaluator of his own learning. The author, when carrying out a review of studies linked to this methodological approach aimed at learning by teaching, highlights that it has a dual function, providing learning opportunities both for those who teach and for those who are being taught. And yet, when focusing on the benefits for the one who teaches, the author adds that "the more complex the teaching activity is, the more opportunities there are to learn by teaching" (DURAN, 2016, p. 1).

Therefore, the act of teaching, of explaining something to the other, represents a learning opportunity, justifying the relevance of incorporating this methodology in classrooms at different levels of education - from basic to higher education. Such guidance gives students the opportunity to learn by teaching their colleagues, through activities such as monitoring, tutoring, tutoring or support classes, among others. The fact of teaching something presupposes the activation of a set of cognitive structures that can favor the process of becoming aware of one's own knowledge or, alternatively, the lack of it. In other words, teaching makes it possible to evaluate one's knowledge, regulate and control thinking, and with that comes the possibility of identifying misunderstandings and uncertainties (WERNER DA ROSA; OTERO, 2018).

The ability to identify what is known and what is not known is associated with the ability to monitor and control the compression itself, as pointed out by Otero & Ishiwa (2014), which has proved to be particularly interesting when it comes to knowledge that apparently would already be understood by the subject. Jaeger et al. (2001) show that ignorance and lack of knowledge increase as knowledge increases. This statement allows us to understand that, although undergraduate students, for example, have been approved in disciplines of their course, when they explain this content to others, they may realize aspects related

to the content that during the course of the discipline has not been identified. Therefore, carrying out activities such as monitoring (support classes) can be an opportunity to assess one's own knowledge.

From this identification and establishing as a cut the monitoring activity, typical in higher education institutions, the present study focuses its problem on the analysis of how the teaching process by undergraduate students can represent an opportunity to learn. Specifically directing its gaze to the possibility of identifying misunderstandings and uncertainties in knowledge. Thus, the core of the study is in the awareness of students who teach about the learning opportunity and the way they reflect metacognitively.

According to the Learning by Teaching methodology, the act of teaching consists of three moments, involving preparation, explanation and feedback. The first is related to the elaboration of the teaching activity; the second to the activity itself; and, the third, to the feedback given by the students regarding the explanations obtained from the person responsible for the teaching activity. These moments are pointed out by Duran (2016, p. 2, our translation) as "elements that form part of the complex process of teaching: preparation, explanation and feedback" and can be identified with monitoring activities or support classes structured in universities. Particularly, it is referring to a project of support classes in the form of monitoring developed by an institution that is the object of study of this research.

This work, entitled "Support Student Project", aims to help students with learning difficulties through individual or group support classes. In it, students who have already passed certain curricular subjects develop support classes for students with learning difficulties. Taking as part of the project the activities linked to support classes for disciplines in the area of Physics, a preparation of supporting students is identified, which is similar to the moments that integrate Learning by teaching, although no specific mention is made of this methodology in that project.

From this identification and considering the possibility that when teaching these supporting students they are also learning, the question arises about the existence of awareness of these academics in relation to their misunderstandings and inconsistencies of knowledge. In other words, does the act of teaching in the form of monitoring provide the opportunity for its executor to have a metacognitive reflection? From this questioning, the importance of this study is justified by bringing to the debate the possibility of learning by teaching and also, of activating mechanisms associated with metacognitive thinking in the form of monitoring and control of understanding, qualifying the teaching-learning processes in teaching higher education, especially in the area of Physics. Still, in terms of valuing support classes, the justification is based on the premise that such activities represent a learning alternative, not only for students with difficulties, but also for those who are in charge of teaching. Thus, these activities can have a greater reach than what is traditionally advocated in support class projects.

Theoretical discussions

Within the studies involving learning by teaching, there is the work of Bargh & Schul (1980) who compared students who study with the objective of passing a test, with students who do so believing that they will have to teach someone else, although the activity does not actually materialize. In this study, an experiment was carried out in which both groups studied a text and then answered some questions about it. Students who believed they had to teach fared considerably better than those who studied for themselves, without the concern or goal of passing it on to someone else. This difference in performance, according to the authors, is due to the fact that the expectation of teaching modifies the learning process, causing the student to select and organize relevant elements of their learning.

Fiorella & Mayer (2014), in turn, performed similar tests, differing only in the fact that they added a group that effectively explained the content studied, without direct contact with the students, only through the explanation of the content to a camera. The results of this study were more forceful than the previous ones and showed that the group that effectively explains something puts more effort and performs better than the students who only prepare to teach, but do not actually do it. Research suggests that teaching can be a learning strategy used even without interaction with other students.

Other researchers have conducted studies in which the teacher interacts directly with the learner. One of the first to do this was Webb (1989 apud DURAN, 2016) who, in his work, concluded that explaining to others offers more opportunities to learn than explaining to oneself. This is because those who receive the explanation can also identify gaps and inconsistencies, requesting clarifications and questioning those who are responsible for explaining. The latter, in turn, will have to look for new information and advance his knowledge.

In this direction, Duran (2016) identifies that learning to teach can be considered as a didactic strategy that over the years has proven to be very efficient. Within this approach, the author highlights three distinct stages in increasing order of improvement in learning: The first is “preparation to teach”, where the student studies and reviews the concepts that he will have to explain. The second represents the “explanation”, where the teaching subject will effectively verbalize his knowledge seeking the dialogue with the learner. And, finally, the “interaction with those who learn”, where those who explain receive feedback that helps them to perceive gaps in their own learning, thus making it possible to solve them. Such gaps have been treated in the literature as learning opportunities and guided teaching methodologies, especially those based on problem solving (HMELO-SILVER, 2004) or on inquiries (LOYENS; RIKERS, 2011).

The ability to recognize one's own misunderstandings and uncertainties of knowledge is directly related to asking qualified questions. Chin & Osborne (2008) point out that knowing how to ask questions is one of the most significant learning processes, therefore, teachers should in their educational activities encourage their students to learn to ask them. However, not just questions, but good questions, characterized by identifying the need to overcome misunderstandings or knowledge uncertainties. In short, being able to ask yourself good questions about the content means reviewing levels of understanding, a kind of meta-understanding.

It is understood, therefore, that regardless of the process that generates the identification of ignorance or uncertainties in relation to it, it is identified that its activation is associated with metacognitive thinking. Metacognition represents a process linked to the awareness of one's own knowledge and the ability to regulate action in the search for success in a cognitive enterprise (FLAVELL, 1976). In the case of identifying the lack of knowledge or uncertainty in relation to a certain knowledge, it is the process of verifying or monitoring knowledge (I don't know something). This, while the student seeks to answer a certain question and develop the consequent control of this understanding (what I need to do to know), which are recognized as processes of a metacognitive nature.

This understanding is associated with the discussions by Nelson & Narens (1994), when they identify that the monitoring of understanding represents the ability to observe, reflect, analyze and experience cognitive processes. Monitoring represents the judgment that can occur in different phases of cognitive action, either before, during or after the explanation. The authors continue mentioning the second component, the metacognitive control, which refers to the decisions that the subjects must take in face of the action to be developed, being linked to the strategies chosen to succeed in their cognitive endeavor, that is, the self-

regulation of the action. In the case of preparing an activity to explain content to others, metacognitive control would be present when they identify what they need to do to fill the gaps found. For them, the efficiency of the cognitive processes depends on the way in which the metacognitive ones are operated. That is, how information is monitored and the ability to control it.

Also according to Nelson & Narens (1994), metacognitive processes are characterized by the displacement between these two components, by the constant search between monitoring and controlling one's own understanding. Such a movement can be considered one of the aspects to be benefited when students seek to learn to explain to someone and, especially, when this explanation comes true. Realizing that, in order to explain the content to someone, their knowledge is insufficient or that there is a misunderstanding, an uncertainty regarding it, students may be triggering mechanisms that lead them to fill these gaps, controlling their own understanding.

From these reflections and discussions, the present study seeks to analyze whether academics in the process of initial training perceive that the activity of explaining to someone can be understood as a learning process, specifically in terms of identifying their misunderstandings and uncertainties of knowledge. For this, the methodological process that permeated the study is reported and then the results are discussed.

Methodology

The methodology developed characterized the present research as qualitative, considering that "it is not concerned with numerical representation, but with the deepening of the understanding of a social group, an organization, etc" (GERHARDT; SILVEIRA, 2009, p. 31).). In this sense, the study turned to identify learning through teaching in the

perception of supporting students (Physics undergraduates participating in the "Support Student Project", linked to a higher education institution). This, taking into account their particularities and without expecting this situation to represent more than itself, that is, not making generalizations. With such delimitation, the research is configured as a case study, since it sought to analyze the perception of a group of subjects.

The project, as already mentioned, aims to help students with learning difficulties through individual or group support classes. Support is intended for undergraduates who request it upon identification of the need and are provided by university students who have successfully completed the requested subject (CORTEZ; DARROZ, 2017). In the project there are preparation activities that are in charge of a teacher who is responsible for supervising the actions developed. In this preparation, supporting students become aware of the content and organize teaching strategies.

These supporting students represent the population to be investigated in this study, having as a focus those who are studying a degree in Physics and who were, at the time of the research, actively enrolled in the institution, facilitating contact. From the universe of eight students who satisfied this condition, all were ready to participate and are considered the subjects of this study.

Thus, to achieve the intended objective, two instruments were used. Initially and as a way of looking for elements to recognize the action developed in the project, simple observation was made, both of the preparation activities with the supporting students (one meeting), and of the conduction of the support classes (three classes with different supporting students). The observation carried out aimed to analyze how these supporters prepared their activities and how they operationalized them with the academics.

In a second moment, interviews (recorded in audio and transcribed in full) were also used, which allowed the identification of characteristics and peculiarities inherent to the activities developed and to the population under study, as the interviewees dialogued and freely exposed their ideas. . Regarding the interviews, Duarte (2004, p. 215) mentions that "if they are carried out well, they will allow the researcher to make a kind of deep dive, collecting evidence of the way each of those subjects perceives and means their reality". Thus, these were performed following the items protocol presented in Chart 1 and were.

CHART 1: Protocol of interviews with the study population

1. Tell us a little about your participation and involvement in the project: how you became part of it, how the project works and what your feelings are about these activities. 2. Describe how you prepare classes/activities: how do you find out about the content to be covered, how do you seek information about the students you will be attending, what information is this, if you prepare classes/activities in advance and what materials you seek subsidy for this preparation. 3. Regarding the content to be covered, have you already identified learning gaps during the preparation of classes? 4. While you are explaining to students, have there been times when you have noticed that there are gaps? 5. During student questioning, did you come across aspects of the content that you were not aware of or were not aware of? 6. Considering the stages of preparing the activities, explaining the content and asking the students, in which of them do you think you can face more situations that lead to limitations in your mastery of the content? 7. Has your participation in the project in its different moments (preparation, explanation and discussion) contributed to expanding your knowledge of the contents covered? In other words, do you think that explaining to others favors the identification of misunderstandings? 8. How do you go about identifying these misunderstandings?

Source: The authors, 2018.

After reading the primary data examined, emerging categories were identified that supported the discussion presented in the next section. In it, speech fragments of the subjects are used, whose language vices were corrected as proposed by Duarte (2004). In these statements, the analyzed students are identified by the letters AA, indicating Supporting Student, followed by a numbering that varies from 1 to 8. The choice of numbering order was based on the order of the interviews.

The speeches transcribed and used in the quotes below are highlighted in italics, in quotation marks and indented.

Results and discussion

The discussion that follows adopts the use of categories to group the responses obtained from the interviews. These categories were established considering the content emerged from the interviews in confrontation with the objective of the study. The analyses, in turn, take as a reference the theoretical contribution discussed and seek through this framework to infer possibilities of responses to the ongoing investigation.

Engagement with the project

The first category encompasses the interviewees' statements regarding their participation and involvement in the project that subsidizes the monitoring activities carried out in the disciplines of the Physics area. Initially, the interviewees were asked about the way they got involved with the project, the way the activities developed are organized and, especially, how they are prepared.

Regarding the first item, it was identified that five students joined the project by invitation of professors of the Physics course and three by recommendation of colleagues who were already participating in it. In terms of their identification with the activities, the academics mentioned that, as students of a degree course, the classroom experience provided by the "Support Student Project" offers several opportunities for learning and personal growth, revealing that the activities are of interest to them. That is, the supporting students participate in the project because they identify with this type of activity and because they believe that it contributes to their formation, as revealed by interviewee AA4:

> I started to participate in the project and I thought the initiative was really cool, because actually they are

> students who help students. This is essential, especially for us at the degree level, I believe it is something that adds a lot for you to be able to learn and have a classroom experience, to be able to take the knowledge you have and pass it on to others.

Another point highlighted in the students' speech was the feeling of gratitude in being able to help others, constituting another factor that encourages them to be a supportive student. According to them, most students who seek project help do so as a last resort in hopes of passing a subject. Thus, they entrust supporting students with the task of helping them to overcome their difficulties. Respondents showed great satisfaction in performing such activity, as seen in the speech of AA3: "I thought it was very good, I felt that I helped the staff. They were grateful and I was even more grateful for having the opportunity to participate in this project that fulfills me a lot".

With regard to the preparation of activities, the interviewees explain that the first class of each class aims to get to know the students and identify their main difficulties so that, from them, they can develop the following ones. In the words of AA6:

> In the first class, I try to get to know the students a little more, to know what material they are using, who the teacher is, I try to talk to their head teacher, I try to know what the main difficulties are, where they have the most difficulty, if it is with basic mathematics, whether it is with interpretation of texts or if it is with the content of Physics itself. From then on, I try to look for questions from the teacher or from our old disciplines that work more on their difficulty.

It is noteworthy that in these classes, not all research subjects reported great efforts in preparing activities, in choosing differentiated or specific teaching methodologies or in relation to the content to be explained. This is justified by the fact that students who request support usually only want help to "solve problems" typical of the area of Physics, since these constitute the form of evaluation used by most teachers, as

mentioned by AA3. Thus, the aim of the supporting student is to achieve success in the face of the objective that the academics who sought help in the support classes obtain approval in the discipline of Physics, or that they become good problem solvers.

In this direction, the same interviewee refers to the fact that the support classes do not demand many studies, since the contents covered have already been seen by them in the Physics course, which makes the action of explaining to colleagues an "easier" task. ". He goes on to point out that:

> To prepare the classes I get some material, sometimes I look for video on the internet or other content to better base my knowledge before arriving in class. But I don't usually prepare so much, because they are usually subjects that I took a short time, so I already have mastery, but even so, I don't go there empty-handed, I try to have a material and study beforehand.

However, this manifestation of AA3 is not shared by all, since five of the interviewees report the importance of preparation activities as expressed by AA6 and AA1, respectively: "We have to study and prepare ourselves, because there may always be a question that we do not know to respond"; "I review everything, look at all the exercises and think if I know the content before going to class". The speech of these supporting students corroborates what was observed in the preparation meeting and in the monitoring activities in which the supporting students were interested in preparing the activity and mastering the content to be addressed.

What was presented in this category shows that the supporting students reveal an identification with the Project, seeing in it a learning potential, both in teaching skills and in content. Among the aspects identified is the presence of the motivational component as responsible for the engagement of supporting students in educational actions and processes. As highlighted by Rosa (2014), it is the desire to accomplish something, that is, wanting to do it, one of the key elements to succeed in cognitive actions. A sentiment that is also defended by the

cognitivists Ausubel, Novak & Hanesian (1983) when they emphasize that learning is related to a predisposition to learn. Authors linked to metacognition, such as Flavell (1976), also emphasize that the evocation of this way of thinking is linked to a feeling of wanting, a decision-making in relation to the action to be developed. This takes into account, among other factors, the experiences lived by the subject that allow him or her to identify or not with the action to be performed.

In the case of this study, the fact that students understand the objectives of the Project and their role in it, as well as show an involvement in relation to the activities to be carried out, represents a possibility that participation favors the learning of the contents for beyond what they thought they knew. That is, engagement can be an indication that the student, having to explain the content to others, feels motivated to prepare. Such conduct leads you to assess your own understanding, as will be discussed in the following categories.

Identification of knowledge gaps during the teaching activity

Within the teaching activities of the Project, the possibilities of identifying misunderstandings and uncertainties of content can be observed, divided into three distinct moments: preparation to teach, explanation and interaction with the student, according to the Learning by teaching approach. Thus, in this second category are the interviewees' statements that represent their perception of their own knowledge, that is, how each subject experienced the moments of exercising metacognitive thinking. The statements concerning this category made it possible to identify which of these moments was more effective in the search for identifying misunderstandings and uncertainties in knowledge, a central aspect of this article.

The identification of misunderstandings during the class preparation stage was noticed by only three of the eight interviewees. They reported noticing, at this stage, the existence of learning gaps in content that, at first, they already mastered. The explanation for this fact was that when

studying to teach someone else, they looked for details that went unnoticed in the study for themselves. They also reported that this new direction was given to be prepared to help students in the best possible way and to answer the questions they could ask, as reported by AA6 and AA2, respectively.

> I think we face many limitations when preparing content, because you are preparing, you are researching for when students ask you. You are already prepared for certain questions, so you research beforehand, study beforehand, in order to help them. We end up studying to help them and in fact we are the ones who learn.
> I usually like to go to class prepared, I really like to have what I'm going to work with, because then it's time and I can meet the needs and doubts of the students.

Two of the interviewees pointed out the class preparation stage as being the one that most contributed to the identification of misunderstandings and uncertainties regarding the content. According to them, this stage requires thinking about what knowledge is necessary for the student to understand their class, demanding greater attention to the specifics of the content and favoring the identification of important points. In this context, the supporting student, in his preparation, carries out a study of the content he will teach, realizing details that could go unnoticed if there was no concern for his students. In the words of AA7:

> I believe that the preparation part is the most difficult. Because then you think: I understand because of that, but if the students don't know this, how will they understand? What am I going to do to explain to them? I also think and if they ask me this or that, as I answer [..] wow, I realize that many times I don't know everything about the subject and I go to study.

This identification that the content is not fully mastered and that there may be questions that he cannot answer, illustrates situations such as the one described by Engle & Faith (2002) about the importance of problematizing as a way of encouraging the identification of uncertainties. Studying with the expectation of teaching others,

encourages the supporter to delve deeper into the content, promoting their approach to the subject, which increases confidence in themselves. In the words of AA8:

> Physics II, for example, was one of the subjects that I liked the least and when I knew that I would give support in Physics II I was scared because I didn't feel prepared in that sense, and studying to give support I ended up learning a lot more and realizing the how much I liked this matter in fact, how good it was. So in that sense of identifying my gaps, overcoming them and learning from it was very useful [...] I passed, but I didn't know that I knew the contents, and also that I didn't know, because there was something that I thought I had understood, but now I see that it doesn't.

In this speech, as well as in those of other interviewees, it can be seen that the class preparation stage was effective in terms of identifying content misunderstandings, making it possible to solve them before the moment of its execution. On the other hand, two of the interviewees declared that they did not identify significant gaps during this stage, a fact that can be justified taking into account that there are supportive students who do not spend much effort in preparing classes, as discussed above. Therefore, they may not be taking advantage of the full potential of this activity, failing to assess their knowledge and, consequently, improve their understanding of the contents.

During the explanation, the identification of misunderstandings was perceived by six of the interviewees and, of these, three believed that this was the stage that most favors such recognition. The explanation stage encompasses all the activities carried out by the supporting student at the time of the class: the contextualization of the content, the use of examples, the explanation of concepts, the resolution of problems, among others. Thus, it requires from the supporter an ability to organize and adapt information in order to facilitate student learning.

In doing so, he will also be becoming aware of his own knowledge, according to Duran (2016, p. 2, our translation), “explaining things to

others is a way of testing how our mind reviews and reformulates information to transform them into knowledge". In this way, explaining something to someone favors metacognitive thinking, constituting an activity of great potential in identifying misunderstandings and, consequently, in improving learning.

In order to take advantage of this potential, it is necessary for the supporting student to be actively involved in the teaching activity, not limiting their explanations to mere reproductions of concepts, but reflecting on their knowledge and on the quality of their explanations. This attitude can be seen in the speeches of some of the interviewees, as in the case of AA8 and AA6, respectively:

> Sometimes, you only reproduce what is in the book and you still haven't internalized it, you haven't learned it, you just reproduced it. And then, while he is explaining it, he verbalizes it, it sinks in and he learns throughout the classes and seeing that there is actually a lack of connections between the ideas or that he needs to study something more. When you go to explain something, you realize that you didn't understand the content so well when your explanation is not useful, you can see this in the subject's expression. I try to explain through my words and the other person doesn't understand, so I know that what I learned, or what I know so far, is not enough for the other person to learn [...] I realize that I need to look for more things , more content and information, you know, learn more.

These examples can contribute to the identification of knowledge gaps, thus, they represent moments of becoming aware of one's own knowledge and the perception that something proves to be inconsistent, in need of a complement. In the speech of AA7, it is possible to identify that, even in the explanation stage, the supporter is already concerned with the questions that his students may ask and even modifies his way of thinking in an attempt to facilitate interaction between them.

> I feel that when you are explaining to others, you have a duty to think about what they might ask you and try to explain it in the easiest way, sometimes you explain in a way that you wouldn't have thought of if it was just for

> you to understand. . I believe that when you are explaining to someone else, you look for different ways of exposing the content and then you may realize that you didn't understand it well.

The questions asked by the students characterize the third stage of the teaching process, where the construction of knowledge takes place through direct and bilateral interaction between the supporter and the supported. It is at this point that the student asks questions about parts of the content that he does not understand, or that were not clear during the explanation. With this, the supportive student is no longer in control of the activities, being vulnerable to questions for which he was not previously prepared and having to seek an answer to the student in his own knowledge. In this way, the higher the difficulty level of the questions, the more learning possibilities they provide. According to King (1998 apud DURAN, 2016, p. 4), "questioning becomes more beneficial when the questions are deeper and require the integration of previous and new knowledge, the reorganization of mental models, the creation of of inferences and metacognitive self-regulation".

In the interviews, the questioning was highlighted as a very significant moment for the identification of learning gaps by almost all the participants and, for three of them, it represented the most important. Only one interviewee, AA3, said that he had never encountered misunderstandings when receiving questions, however, he explained that the students he attended usually did not ask them. In his words:

> I didn't come across learning gaps, but not because I'm super prepared, it was because most of the time they don't really ask, so sometimes you're even disappointed because you want them to demonstrate their doubts and they don't. But for a student to come and talk about something I didn't know or for him to ask me something that I hadn't realized before or that I couldn't answer, it didn't happen.

In this way, the need for active participation of both involved in the teaching activity is evident, as it favors the construction of

knowledge in a more complete and complete way, not just the memorization and repetition of concepts, both by those who learn and for those who teach. . However, it is up to the supporter to encourage students to question them, as they are often used to adopting a passive attitude towards learning. In this sense, it was noticed in the interviews that the supporting students play this role well and understand the importance of questioning for the learning of their students and themselves, as can be seen in the speech of AA2:

> I think the most important part of the class is the student question, and I always urge you to really ask. Always after I explain something I say: do you understand? Are you understanding? If you don't understand, ask. So I keep asking them to ask questions. Because that way I can also get out of my point of view. Because sometimes it's difficult, when you're teaching you start to systematize and after a while, you always start doing it the same way, so the fact that the student asks already makes you think in a different way, I think that adds a lot knowledge for learning.

Another potential highlighted by the interviewees, involving the stages of explanation and questioning, was the identification of communication difficulties, such as the difficulty of verbalizing concepts in a simple and accessible way to the student. One of the factors that contribute to the existence of this difficulty would be the lack of previous knowledge in the students, which requires the resumption of concepts much earlier than those discussed in class. In view of this, the supportive student needs to reformulate his explanation and reorganize his thoughts, favoring the control of his own understanding.

Thus, in this category, the potential for identifying misunderstandings during teaching activities is evidenced. In the three stages, the student who teaches faces situations that lead him to face limitations in his mastery of content.

Contribution of activities to qualify learning

The third category covers the interviewees' statements related to the qualification of learning resulting from teaching activities. It seeks to identify the perceived potential of supporting students to learn by teaching, especially in terms of learning through the activation of metacognitive thinking, associated in this study with monitoring and controlling understanding.

In the development of teaching activities, as previously explored, the supporting students were sometimes faced with a lack of knowledge or doubts that may originate from gaps in their learning. This identification may be related to the activation of metacognitive thinking, since the subject, when faced with them, exerts a conscious mechanism of control and monitoring over his knowledge. That is, the analysis of essentially cognitive actions carried out when teaching, leads to an awareness of the level of understanding that the subject has, perceiving what he knows, or does not know to achieve his goals, which in this case refer to helping another person. person in understanding certain content.

By identifying their misunderstandings, the student begins to exercise metacognitive control of their learning, analyzing and making decisions about the strategies they will have to develop to overcome their learning gaps. In this way, self-regulation acts as a control mechanism of cognitive processes, leading to the reformulation of concepts and the reorganization of mental representations (ROSA, 2014). The qualification of learning, in view of this conception, takes place through the regulation and control of understanding as the subject activates them in the development of teaching activities.

In the interviewees' speeches, it was possible to identify elements that refer to the use of metacognitive thinking, especially in the identification of learning gaps and, then, in the way they were resolved. Such dynamics can be observed in the speech of AA3, who cites as an example a situation that occurred during one of his classes:

> Yes, there was a time when I gave Physics I to engineering and they were having a lot of difficulty with the issue of scientific notation and unit transformation. And then when I went to teach them, I realized that I didn't have that very clear in my mind either, so I made some mistakes, some confusions that I managed to recover later in class. I was able to analyze and identify my error. When you are going to explain something that you saw a short time ago, or that you saw a long time ago, obviously in addition to rekindling this concept in your head, you will probably learn and realize things that you had not noticed before, so teaching is a great way to learn and is a very good exercise for teaching and personal development.

In the speech, it is possible to verify that he was not only able to identify the existence of learning gaps, but he was also able to find their cause and correct it, without needing to consult study material or a teacher. The ability to find, alone, the solutions to its limitations, whether studying and preparing for the class, or even during the explanation, through the review and restructuring of the information already existing in the cognitive structure, is shown as one of the skills developed when teach someone else.

When comparing the learning that occurs when the student studies for himself, or for a test, with the learning resulting from teaching, the interviewees were unanimous in emphasizing the superiority of the latter. The motivational aspect is considered one of the factors of this finding, in addition, the contact with the other, which can bring different ways of thinking. Obstacles faced when having to adapt explanations to those with which students are already used were also mentioned, as a factor that contributes to greater learning when teaching others, as described by AA1:

> Teaching certainly expands my knowledge, because it's a moment when you change positions with the teacher. There was a moment when the teacher taught you the content, but from now on you have to take all this content, review and reformulate it in a language that you can explain and in a

> language that is adapted to the head teacher of the class in which you are studying. performs support. And the discussion is what favors the most, because there are moments when they question things that you didn't ask your teacher, so it's the moment that favors a lot.

As evidenced in this excerpt, in the interaction with the students, questions may arise that the supporter never paid attention to, making him reflect on this new aspect of the content with learning possibilities. Similarly, AA4, in his interview, highlights that, when explaining, it is often necessary to pay greater attention to certain details of the content, remembering concepts and fixing that knowledge. With such dynamics, learning occurs more effectively than it would in the traditional process, through individual study aimed only at passing a test:

> I think teaching other students makes you learn much more than a class you study for yourself. Mainly because you have a contact with another person that you need to explain, sometimes in detail, certain things and it makes you stick with the content more. You even take a step by step like this, remember some basic concepts and fix it well because when you are studying for yourself there are some things that are already in your subconscious and you miss it. But there, teaching, you reinforce these details and each time you reinforce this, you record this knowledge more and you can even identify failures in your learning.

The explanation stage discussed in this last category can be analyzed by the questions that the students make to the supporters, allowing the freedom to question, to ask questions during the explanations. Such conduct represents a learning opportunity not only for the supporting students, the focus of this study, but also for those who sought these classes. In this regard, studies such as the one by Phillips et al. (2017) show that the formulation of questions, via the formulation of problems in Physics, for example, involves perceiving a gap in understanding, identifying and articulating existing knowledge and those that need to be incorporated into the subject's cognitive structure. The

same authors in another study (2018) point to problematization as the intellectual work to identify, articulate and motivate the identification of gaps or inconsistencies in the current understanding of a community (such as Physics, for example) or someone (such as students). According to the authors, asking good questions is an activity of professional science, but it is also part of the classroom, because in both cases what is at stake is the search for knowledge.

This ability to monitor and control one's own understanding, involving the formulation of questions as a mechanism to activate the identification of misunderstandings, as previously reported, has been investigated from different possibilities. Werner da Rosa & Otero (2018), for example, show that through the formulation of questions, students can verify their own misunderstandings and uncertainties of knowledge when reading scientific texts. The results of this study showed that when asking questions, students can activate a set of mechanisms capable of monitoring their understanding and thus identifying what they do not know, making it possible to qualify their readings and knowledge about the content under discussion.

In short, the activities carried out by the supporting students had contributions to their learning, which is in agreement with studies that show that teaching someone represents a learning strategy (BENWARE; DECI, 1984). Added to this, it was observed the use of metacognition in the monitoring and control of learning, portrayed by the awareness of misunderstandings of knowledge.

Conclusion

The study sought to identify the perception of eight students, undergraduates in Physics who act as monitors in the "Support Student Project" in the investigated institution, about the opportunities to learn by teaching. This initiative is aimed at offering support classes for

students with learning difficulties in this field of knowledge. For the aforementioned study, the contributions of participation in this Project were investigated as a way of qualifying the student monitor's own learning, through the identification of misunderstandings and uncertainties of knowledge during the activities of preparing the class, explaining the content and interacting with the student. The focus was on analyzing whether, when explaining, supporting students also learn and whether this is accompanied by an awareness of their own knowledge.

The students' speeches, guided by semi-structured interviews, revealed that they identified in the practice of teaching the other the existence of several learning opportunities. Also, that these enabled the development of skills of monitoring and metacognitive control of their knowledge, leading them to the identification and overcoming of misunderstandings and uncertainties of content.

That said, it is possible to understand that the support class is an activity rich in opportunities for personal and cognitive development, and can be implemented as a teaching methodology insofar as it favors learning, both for students with learning difficulties and for those who dedicated to teaching these classes. In this way, students are encouraged to engage in projects similar to the one reported in this work and to take advantage of all the potential of learning through teaching, since it qualifies the process of understanding the concepts.

On the other hand, the study also pointed out another fundamental aspect in relation to learning, which is the importance of favoring situations that allow students to perceive gaps and uncertainties in understanding. These are, as well remembered by Phillips et al. (2017; 2018) and Otero & Rosa (2018), which guide the advances of science and could be fostered in science learning.

According to the authors, the ability to formulate questions or problematize a situation can be an alternative for students to venture into identifying these misunderstandings. However, they point out that

the most significant of this is the moment before the formulation of a problem, which is related to an uncomfortable feeling that something is missing or wrong. So, "the challenge is to identify the source of the unease, to find out what the gap or inconsistency in understanding is" (Phillips et al., 2017, p. 020107-2, our translation). Enabling debate in the classroom could be the first source and this would lead to the possibility of formulating good questions and problematizing situations based on misunderstandings and not just for their identification.

Thus, and as a conclusion of this investigative work, two future studies by the authors of this article are mentioned, one aimed at analyzing didactic interventions supported by Learning by teaching from the analysis of the results of the present study in terms of monitoring activities; and, another investigating the structuring of methodological approaches that favor students to identify gaps and inconsistency of knowledge, as is done in Science, leading them to good questions.

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