THE QUESTIONING AS A SUPPORTER OF CRITICAL THINKING IN PROBLEM SOLVING

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Abstract

Learning through problem solving promotes critical thinking among students, essential for acquiring new skills to overcome the obstacles that will arise in the course of the life of any citizen. To achieve this goal, the teacher should use the questioning in order to construct questions which promote the development of critical thinking of the students.

Using questions that try to value and evaluate the reading of the problem statements and their interpretation, the teacher aims to obtain clear answers in which the students present their opinions, points of view and arguments that support them.

In a previous work, we shared an experience of teaching, with 23 pupils of the 5th grade of basic education, carried out in a Mathematics class in which three *end lesson* tasks were implemented. The comparative study of the students' resolutions revealed that the use of the questioning between these tasks allowed the students to present a positive evolution in their capacity for critical interpretation, analysis and reflection.

In order to keep the questioning present, supporting the student in the performance of his activities, we propose a problem solving support script. With the implementation of this instrument in classroom context, it is intended to assess its impact on the evolution of student reflection and metacognition, helping him to select and carry out a set of actions, in order to arrive at the desired solution. In this way, we believe that students will develop the skills of reasoning, analysis, reflection, understanding, interpretation, decision making and their critical thinking.

In the future, it is intended to put into practice this teaching tool encouraging teachers and future teachers to implement it, since it is a simple tool that integrates easily understood questions. This resource will give students the opportunity to become more autonomous and to enhance their cognitive abilities.

In our view, it is desirable to develop more dynamic and challenging methods and instruments, such as those we propose, in contrast to traditional teaching that is rooted in schools.

Keywords: questioning; *end lesson* tasks; critical thinking; argumentation; problem solving support script.

1 INTRODUCTION

The need for children to learn, at an early stage, to raise their own questions, to formulate and substantiate arguments, to make decisions about what to do or to believe, are the main factors to take into account when looking for new teaching tools, which stimulate their good thinking habits. In this sense, rather than forming citizens with static knowledge, it is currently intended that education and training systems instruct students to perform complex activities in different contexts and to be able to solve challenging problems by presenting innovative solutions.

Given that problem solving is an activity that drives higher cognitive abilities, it is sought to use questions with different characteristics and formats. That is, questions whose purposes are to value and evaluate the reading of problem statements and their interpretation, in order to obtain broad answers, in which the students present their opinions, points of view and arguments that support them. In this sense, the questioning is presented as a fundamental tool, in the context of the classroom, to increase the students' school performance, enhancing certain capacities such as understanding, reasoning and creativity, contributing to a good meaningful learning ([1]).

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The construction of valid and reasoned questions and arguments is one of the most important challenges in the educational context, because it makes possible the development of critical thinking in students through questioning and argumentation. In addition, it contributes to the classroom environment being conducive to questioning, thinking and argumentation on the part of students, encouraging them to frequently present more complex questions.

Following a teaching experience ([2]) implemented in a Mathematics class of the 5th grade of basic education, in which were made available at the end of each class, problems that we named end class tasks, will be presented in this work a problem-solving guide. Through this script, we sought to identify the strategies and knowledge that the participating students mobilize, as well as to analyse the interpretation, reflection and analysis capacities that they use in solving problematic issues.

2 THEORETICAL FRAMEWORK

Adopting a new paradigm of more active learning on the part of the student, as an alternative to the information exhibition, it is intended that the school context will provide students with the acquisition of new skills. These skills include argumentation, reading, writing, questioning, problem solving, creativity, critical thinking, logical reasoning, collaborative work, valuing the interpersonal relationships that will develop throughout their lives ([3]).

In an active learning environment, it is desired that the teacher will play the role of information collaborator or guide, that is, guides the students in their discoveries, always encouraging them to ask their questions, while they assume a role of explorers of their own learning ([4]).

Encouraging questioning is a key strategy for the teacher to turn a listener into an active learner with the ability to think, question, and build their knowledge. In addition, students to ask questions, of a high cognitive level, need confidence, curiosity, conviction and, above all, a teacher who encourages them, also posing complex questions and giving complete and finished answers ([4]).

Asking questions is a cognitively complex process that not all students are able to use, simply because they are still afraid to put their questions in an open way, lest they be criticized by the teacher or ridiculed by colleagues. To combat this fear, in ([5]) the author states that before asking questions, the student needs to think about what he/she knows, what he/she does not know and he/she wants to know.

2.1 The questioning in an mathematics class

The questioning in teaching, namely in mathematics is considered an essential component of the teacher's oral discourse. A class with questions is considered a participated class, while a class with no questions is said to be an expository class.

A study developed in ([6]) confirms that the use of the question allows a greater participation on the part of the students. Through questioning, the teacher is able to control the knowledge of the students, from a sequential process and covered in previous concepts, using activities of discussion, communication of ideas and exercises of thought. The questions, depending on how each teacher conceives the learning of mathematics, can direct students' knowledge to certain concepts ([6]).

In this sense, the application of questioning in the classroom can have different purposes, such as creating knowledge, developing different abilities, acting as a test of knowledge and disciplining students, depending on the conceptions that each teacher has about teaching and learning Mathematics ([7]).

The questions presented by the students should be considered as an incentive for active learning, through which they promote understanding, guide and direct the activities of the classes, increasing their interest and involvement. In this way, teachers access to previous concepts and to difficulties of the students ([8]).

Students' autonomy and responsibility can also be worked through the questioning and activities that promote it, such as problem solving, group work, debates, discussions and experimental activities, thus allowing the student to make an active questioning ([4]).

Recent researches ([9], [10]) present the interaction pattern between teacher and student in the classroom, stating that: the formulation of questions is mainly done by the teacher, about 40 questions per hour. In addition, the teacher's questions are usually of low cognitive level and the lack of pedagogical intentionality conceives the questions an exclusively academic character, that is, without

contextualization with the quotidian or CTS character (Sciences, Technology and Society). On the other hand, teachers are not able to wait more than a second for the students' responses. When students ask questions they only do three questions per week. Besides being few, they have a low cognitive level, are not scientifically correct or even decontextualized. There is also a lack of encouragement to students to ask more questions, but rather to respond to the teacher's direct questions.

Teachers' questions should be considered as a good tool to promote critical thinking and creativity, stimulating student thinking, and helping the teacher lead the classroom activities. In this way, it accesses the various conceptions of the students and negotiates meanings, allowing the student to obtain feedback on the learning process, keeping the attention of the student focused on the class, involving all the students and maintaining a good rhythm of work.

In this process, students are encouraged to be autonomous, questioning, curious, interested and creative in the classroom, arousing the interest of knowing and learning what is new and investigating what has already been discovered. Thus, students are given the opportunity to explain, justify and evaluate their ideas and those of their colleagues ([11]).

The teacher when questioning accesses the previous knowledge of the student, discovers their interests and motivations, as well as evaluates the comprehension of new concepts approached at the moment, due to the high formative value and diagnosis that the questioning presents ([3], [12]) However, the teacher should take into account that questioning, listening and responding to students are demanding tasks and how the teacher plays them is determinant for classroom communication and the regulation of student learning ([13]).

The various researchers ([9], [10]) who study the formulation of questions and the most appropriate way of applying them in a classroom context, affirm that the way in which teachers present the questions, of low or high cognitive level, is relevant to the development of the learning strategy, to stimulate the thinking and the growth of students' reasoning abilities.

The good questioning in the classroom context requires, on the part of the teacher, a good preparation. In ([6]) the author presents a set of aspects that the teacher must take into account when organizes his questioning, beginning by stating that some questions will have to be prepared in advance. The students' level of reasoning is not the same for each one, asking questions with different levels of difficulty, giving time to pause after asking the questions, asking the questions to the group, and then individualizing questions later, will allow the teacher to receive feedback on the students' knowledge, will favours a good questioning in the classroom environment.

Student's questions presented in direct contact with colleagues or the teacher, according to ([14]), allow students to feel safer to ask questions of higher cognitive level, which require a lot of time for a deeper analysis. However, the questions, considered interesting and relevant, for the content addressed in the educational context are proposed by the teacher to the student. Nevertheless, the questions formulated by students promote their learning and stimulate their cognitive and metacognitive development. In this sense, the students who construct their questions learn more, compared to the students who adopt the questions asked by the teacher.

2.2 The critical thinking and problem solving

The formulation of valid and reasoned questions and arguments is one of the most important challenges in the educational context, because it allows through the questioning and argumentation, the development of critical thinking in students.

In this way, problem solving allows us to value and evaluate the interpretation and reading of problems, as well as the students' well-founded answers, where they present their ideas, different points of view and arguments that validate their an answer. For this challenge to materialize, it is necessary to overcome some of the obstacles present in the classroom, such as mastery of the teacher's discourse, as well as to replace the questions of low cognitive level with others more elaborate and grounded ([15]).

In this sense, it is intended through problem solving to gauge knowledge about the forms and knowledge that students have when solving problems and the most effective methods they use ([16]). Thus, the use of a conscious and informed questioning, when applied in the classroom, will contribute to an improvement of educational practices and student learning, which are a strong incentive for success in educational context ([17]).

An important aspect of effective questioning is the way students deal with the teacher's comments to their answers. In this sense, the teacher should not effusively praise every right answer, but rather the exceptional ones, encouraging the most insecure students, regarding their correct answers. The teacher needs to accept different answers, even the incorrect ones, always alerting the student, first to the aspects that are correct, giving clues or clues, to help him perceive the incorrect parts ([3]).

In this way, the comments of the students should be used by the teachers to be questioned, through the question *Why?* or by asking them to explain their reasoning by stimulating their critical thinking. The teacher's ability is crucial to formulate questions which direct oral and written discourse in the direction of mathematical reasoning. Since, the teaching of Mathematics is carried out using a set of actions carried out by the teacher, based on his / her knowledge and the one of the students and their forms of learning, as well as their curriculum and professional practice ([18]).

In order to contribute to the development of critical thinking in an educational context, the questioning was implemented with the goal of constructing questions that promote the development of students' critical thinking. With this purpose, problems were implemented that were made available at the end of three classes, which were called *end class tasks*.

In the 2014/15 academic year, a teaching experiment was carried out in a Mathematics class, in which three *end lesson tasks* were implemented, with 23 pupils (14 female and 9 male) of the 5th grade of basic education. With this study, it was tried to demonstrate that the students in questioning seek to arrive at the best strategies and solutions to reach certain objectives, with the maximum perfection, thus reaching reflective knowledge ([19]).

According to the results obtained, it was possible to characterize the strategies and knowledge that the participating students mobilized, as well as the interpreting, reflection and analysis capacities that they used to solve the classroom questions ([2]).

In addition to providing the teacher and the student with the informative feedback, the *end lesson tasks* demonstrate the level of learning, identifying the difficulties experienced by the student in a particular domain. Moreover, they also allowed an analysis of the learning and to intervene, in a logical and timely manner, directing the student on the right path. Through the implementation of these problematic questions, formative evaluation allowed us to diagnose essential aspects, namely, the competence they presented for solving problems and their knowledge of the content in question ([20]).

The questioning was always the basis of the activity developed, as it was intended to encourage students to develop critical thinking skills, such as solving problems, thinking, reflecting, communicating and achieving objectives, being autonomous, participative and confident in the way As they face mathematics ([20]). Through the questioning, more active classes were provided, stimulating students who previously assumed the role of listeners, participating more, asking questions, showing more interest in getting involved and engaging in class ([5], [8])

3 PROBLEM SOLVING SUPPORT SCRIPT

Taking into account the results presented in ([2]) and with the purpose of consolidating the preponderant role of questioning, as the starting point to help students overcome obstacles, unblocking them from their impasses by making questions, supporting them in all steps ([1]) a support instrument for the students was constructed: *problem solving support script*.

The elaboration of this resource was supported by the FRISCO approach ([21]) in order to establish concepts between the issues elaborated and the six established elements (Focus, Reason, Inference, Situation, Clarity and Overview), with the purpose of Critical thinking in the students ([20]).

At the outset, the guideline consists of seven questions and a set of suggestions that more simply summarise what is asked in the main question, helping the student to confidently and significantly reach the answer (see table 1).

Table 1. *Problem solving support script: 1st step*

	1. Describe the problem by your own words.
a	Identify the main parts of the problem
b	List the most important concepts that help you synthesize the problem
c	Do not forget to refer the data
	2. What do you want to solve with the problem?
a	Find the problem situation
b	Reflect on the main question
c	Analyse the solutions presented, if they exist
	3. What are the keywords that appear in the statement?
a	Find the most relevant concepts
b	Check if there is any relation between them
c	Reflect on the concepts identified
	4. What are the keywords that appear in the statement?
a	Indicate the values
b	Organise mathematical representations
c	Check if you have collected all the necessary information
	4.1. What connection exists between the data?
a	Organise the data
b	Make combinations between data
c	Analyse all hypotheses of association between them
	5. What strategy do you intend to use?
a	Consider several strategies
b	Validate these strategies
c	Select the one that you consider most appropriate
	6. Why did you adopt this strategy?
a	Present arguments for your choice
b	Do it
c	Reflect on the problem execution process
	6.1. What are its weaknesses and strengths?
a	Present the advantages of this strategy
b	Present its disadvantages
	6.2. How could you improve the weaknesses?
a	What you will change in the strategy to make it more effective?
b	What changes do you would make?
	7. Reflect on the whole resolution process and how you thought along the way.
a	Indicate the difficulties you felt
b	Point out the moments where you were at ease
c	Suggest what you changed in your thought process
d	Identify your failures, if there is any
e	What did you learned by solving this problem?

The suggestions presented, for each question, support the student to consciously decipher what is asked of them. In addition, it aims to develop, in students, high-level cognitive skills, which will make them increasingly autonomous. Subsequently, in a second step the student will use a script, which only includes the main questions, from 1 to 7 of Table 1, without the subdivisions.

In a third step, we intend to verify if the student has internalized the questions in table 1, without having to resort to the supporting script. The aim of this last phase is to determine if the student is already capable of applying his / her critical thinking skills and if the student is more autonomous in the performance of his / her activities, using the questioning as a promoter of critical thinking ([20]).

It should be noted that it is not only the mathematical reasoning that students are expected to use, but also their critical thinking. The first allows one to immediately interpret the problem and evaluate the alternatives, while critical thinking, more methodical and deliberate, instils the capacity to be more attentive to the discovery of gaps, which otherwise would go unnoticed.

To that end, students should be confronted by the teacher with challenging and motivating problems, which arouse their interest, as opposed to routine exercises, which only limit students to memorize and give quick answers ([18]). Therefore, it is necessary to offer a wide variety of problems to the students so that they have the opportunity to resort to different strategies of resolution, to reflect, to analyse and to reason about the solutions that they find. And, finally, to manage their knowledge and resolution processes in an organised way to apply in other problematic situations ([16]).

In order to encourage the use and construction of critical thinking issues in the context of the classroom, a table (table 2) was elaborated in which the student is presented with the aid Of the teacher ([20]).

Table 2. *Script Questions - What do you want the student to do? - Suggestions*

Script question	What do you want the student to do? - Suggestions
1	Understand the problem; Interpret and use the information; Summarize; Communicate and translate what you have understood into a smaller version.
2	Decipher what is intended to be discovered at the end of the resolution process, develop a logical reasoning, using reflection and interpretation, analysing the statement until completing what is requested.
3	Gather the concepts that will help him come up with a solution. Analyse and select concepts. Look carefully at the concepts and decode the most relevant concepts.
4	Analyse the data collection for a complex whole. Identify the data that help him to arrive at possible solutions, being consistent with the data collected.
4.1	Decipher the relationship that exists between them, through analysis and investigation, reflection and hypothesis assumption.
5	Opt for a way forward, concretizing a plan or proposal of a set of operations to execute, that is, it chooses the strategy. Use the information, methods and contents previously discussed in the formulation of alternative solutions. Control the decision-making process. Consider and weigh alternatives, analysing other points of view different than yours.
6	Justify the option for a certain strategy, among several hypotheses of choice. Think, reflect and try not to make mistakes.
6.1	Argue, indicating reasons, evaluating and observing the facts. Recognise the consequences of the actions proposed and mention the relevance of the strengths.
6.2	Improve the resolution, filling the mentioned weaknesses.
7	Think critically about your work and reflect, learn and record what you did wrong not to repeat it in future situations.

Although this script was built for the purpose of being implemented in the area of Mathematics, it is easily generalizable to problems in other areas and even our daily lives. It is intended that students, through a questioning oriented, develop an effective questioning and high-level cognitive skills, becoming autonomous and able to solve their own problems, reaching conclusions without being given clues.

4 CONCLUSIONS

Nowadays, students are increasingly demanding a dynamic school where their voice is heard, where dialogue between pupils and between pupil and teacher prevails, where children have more confidence, autonomy and initiative, and their interests and needs are valued.

In this sense, teachers should value students' interests, adopting more creative strategies that capture their attention and that lead them to communicate and, essentially, to reflect on their ideas. Since reflection on the intentions, representations and strategies of intervention facilitates the construction of knowledge, allowing the acquisition of new ways of learning, of understanding, of intervening in certain situations, of solving problems, thus allowing for awareness, analysis and interpretation of what is done.

The questioning is undoubtedly a dynamic and fundamental strategy to combat the traditional method of teaching, which is limited to the exposition of contents inhibiting student intervention. In this way the questioning presents itself as a more active and attractive methods, capable of encouraging a greater participation of the students, thus demonstrating that they are able to deal more safely and effectively with the problems that arise in their daily lives ([20]).

The problem solving script is not yet implemented. However, it is expected to be an excellent aid tool not only for the students but also for the teacher. For the students, because it will guide and support them in the concretization of problematic situations directing them to an effective way. For the teacher, because it facilitates their work, since they do not need to put the questions out loud, they also have the opportunity to make sure that the students have reached the defined objectives, when correctly interpreting the problematic issues with the support that this script suggests.

It is hoped that the contribution of the script along with other strategies will replace the exposure of content by more dynamic and challenging methods and instruments for students. In this way, students will be able to reason deductively and rigorously, make decisions, solve problems effectively, motivate them to learn and enrich their knowledge ([20]).

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